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THE PORT ORCHARD DRY DOCK, built for the U. S. navy at Seattle, Wash., was formally opened April 23, by the entrance of the monitor "Monterey." The dock is of timber construction, and was illustrated and described in detail in our issues of May 19, 1892, and Jan. 24, 1895. The contract for the work was awarded in Oct., 1892, to Byron, Barlow & Co. The general dimensions are as follows:

Length over all.....	.....749 ft. 8 ins.
Length over coping.....	.....650 " 5 "
Length on floor.....	.....573 " 7 "
Width over coping at middle.....	.....130 " 1 "
Width on floor.....	..... 67 " 1 "
Width of entrance	..... 92 " 8 "
Height from floor to coping.....	..... 39 " 3 "
Height from sill to high-water line.....	30 " 0 "
Height from keel blocks to high-water line..	28 " 2 "

THE ELECTRICAL EXPOSITION, held in connection with the nineteenth convention of the National Electric Light Association, was formally opened by Governor Morton, on the evening of May 4, in the Industrial Building, New York city. Simultaneously with the pressing of the key the current, which was furnished by the new Niagara generators, fired cannon in Augusta, Me., New Orleans, La., St. Paul, Minn., and San Francisco, Cal., and on its return turned on the lights of the exposition hall. In a few moments telegrams were read from San Francisco and London, announcing the receipt of the opening message. The speakers' gallery was illuminated by a frame of McFarland Moore's vacuum tubes, which gave sufficient light for the reading of the telegrams. The hall is crowded with exhibits representing all branches of the electrical industries. The exposition will continue until May 30. We shall present reviews of the exhibits in later issues.

A PRE-ARRANGED RAILWAY COLLISION is to be one of the attractions at the opening of Buckeye Park, a pleasure resort 25 miles south of Columbus, O. The Columbus, Hocking Valley & Toledo Ry. has assigned two 35-ton locomotives, which have outlived their usefulness for economical service, and to each of these will be attached three old gondola cars and a caboose. A siding 1,000 ft. long has been laid, connected at each end with the main track, and the trains will be started from points about half or three-quarters of a mile from the middle of the siding. A trial trip has showed that a speed of 45 to 50 miles per hour may be expected. The engines are to carry 120 lbs. boiler pressure, and are to have the throttles wide open. What means will be taken to protect the spectators in case of the possibility of a boiler explosion we do not know. The above particulars have been furnished us by Mr. W. H. Fisher, General Passenger Agent, who is arranging for a large excursion traffic to this novel attraction.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the derailment of an express train on the Baltimore & Ohio R. R., near Washington, Pa., April 30. It is said that one of the engine truck axles broke, and the engine, tender and baggage car were upset. The fireman was killed and the engineman and express messenger were seriously injured.——An embankment weakened by a flood caused the track to settle and derail a train on the Illinois Central R. R., near Raymond, Ia., April 28. The engine, baggage car and smoking car passed in safety but the three rear passenger cars were derailed and about 12 persons were slightly injured.

FOUR EXPLOSIONS IN THE SUBWAYS of the New York & New Jersey Telephone Co. occurred in Brooklyn April 30, and in two cases the heavy iron manholes were blown high into the air. Nobody was hurt.

THE EXPLOSION OF A STILL at the Standard Oil Co.'s works at Constable Hook, New York, on May 2 caused a large quantity of benzine to catch fire, and it was with difficulty that the fire was prevented from spreading through the yards. Nobody was hurt.

THE COLLAPSE OF A BUILDING at Cincinnati, O., resulted from the explosion of a gasoline tank in the cellar, May 4. Six dead bodies were taken from the ruins and many persons were seriously injured. The building was a five-story brick structure, the upper floors of which were let to lodgers.

TWO RECENT FIRES AT CRIPPLE CREEK, COLO., have almost entirely destroyed this new and famous mining center.

A FIRE IN AN ANTHRACITE COAL MINE, which has been burning since 1873 in one of the veins of the Anchor colliery, at Heckscherville, Pa., causing the abandonment of the mine together with two others in the vicinity, has been explored recently, and found to be still burning, but in a contracted area. It has now been decided by the owner, the Philadelphia & Reading Coal & Iron Co., to wall in the burning vein, and to sink slopes on each side of the confined area so that the adjoining coal can be reached.

COMPRESSED GAS FOR LIGHTING RAILWAY CARS is to be carried in 2-in. pipes through the streets of Washington, D. C., to connect the works of the Pintsch Compressing Co. with the stations of the Baltimore & Ohio R. R., Baltimore & Potomac R. R., and Southern Ry., and also to the river front where it will be used for charging illuminated buoys for the Potomac River navigation. In reporting the bill, Senator McMillan, of the committee on the District of Columbia, alluded to the project as follows:

> Pintsch gas is used for lighting railway cars and buoys. The object to be gained is the lighting of the railway mail cars starting from Washington, thus doing away with the oil lamps, so dangerous in railway mail cars especially; also the furnishing of gas for lighted buoys on the Potomac. The Pintsch gas is in use all over the country, and there is no experiment in the matter. Indeed, the bill simply provides for a commercial necessity.

THE IRON PROMENADE along the beach at Atlantic City, N. J., is now under construction. It will be about 7,000 ft. long and 40 ft. wide, supported on columns sunk into the sand by the water jet system. A large traveler is used by which four columns can be sunk at once. The work is being done by the Phoenix Iron Co., of Phoenixville, Pa.

THE SETTLEMENT OF THE EMBANKMENT approach to the new Delaware River bridge of the Pennsylvania R. R., has caused an interruption to the traffic. The weight of the earth seems to have broken through a surface crust and sunk into an underlying bed of soft material, causing the ground to rise in waves on either side of the embankment. A timber trestle approach was at once commenced for temporary use.

THE THIRD ELECTRIC LOCOMOTIVE for the Baltimore tunnel of the Baltimore & Ohio R. R. has been shipped from the works of the General Electric Co., at Schenectady, N. Y., and as soon as it is put in service the three engines will handle the passenger as well as the freight traffic of the tunnel, the present coke-burning engines used with the passenger trains shutting off steam before entering the tunnel. The engines weigh 96 tons, and have a capacity of 1,500 HP., while one of them is said to have attained a speed of 80 miles per hour.

THE GARBAGE DISPOSAL QUESTION IN NEW YORK city, like Banquo's ghost, will not down. Col. Geo. E. Waring, Jr., M. Inst. C. E., Commissioner of Street Cleaning, recommended on May 5 that of the bids received on April 27, the one made by the New York Sanitary Utilization Co. for the disposal of garbage alone at $80,990 a year for a term of five years should be accepted. The bid of Mr. Edw. Duffy to do the work for $60,000 was rejected on account of the experimental status of the proposed plan; and that of the Merz Universal Extractor & Construction Co. was rejected simply because it was higher than the one recommended for acceptance, being $144,000. The Merz Co. has notified the city that it will take steps to compel the acceptance of its bid of March 26, at the same price as named above. Col. Waring recommended the acceptance of this bid, which the Merz Co. claims was equivalent to an award, but the Board of Estimate and Apportionment did not approve the award and directed Col. Waring to call for new bids. There were also received on April 27 two bids for disposing of garbage, ashes, street sweepings and other refuse, as noted in our last issue. Col. Waring rejects these bids on the following grounds: He estimates that ashes and street sweepings alone amount to 1,928,000 cu. yds. a year, or 5,280 a day, and that this material can be deposited at Riker's Island for $136,888 per year, making from 50 to 60 acres of land. Mr. Herbert Tate has offered to pay the city $245,000 a year for the privilege of picking over the rubbish of the city, aside from garbage, ashes and street sweepings. The "unsalable residuum," Mr. Tate thinks, "can be turned to profitable account in the production of steam." Pending the settlement of the claim of the Merz Co., it is said that the whole matter is laid over.

PROPOSALS FOR A NEW WATER-WORKS TUNNEL under Lake Michigan at Chicago will be received on May 9, as stated in our advertising columns. The tunnel will be of brick, 10 ft. in diameter, and about 2½ miles long. Mr. W. D. Kent is Commissioner of Public Works.

A NEW WATER SUPPLY FOR CINCINNATI is authorized by a bill which has just passed the Ohio legislature. The bill provides for the appointment of five commissioners by the Governor of Ohio, on application of the Board of Administration. The commissioners may issue $6,500,000 of bonds for works or let a contract to a construction company for a plant.

DAMAGES FOR DISCHARGING SEWAGE INTO A stream have been awarded against the city of Richmond, Ind., according to a press dispatch. The suit was brought by some woolen manufacturers, whose mill is located on White Water River, into which sewage is discharged by the city. The suit was for $20,000, and the court allowed $1,350, "on the ground of decreased rental value." The court is reported as having ruled that the city had the right to discharge sewage into the river, but was responsible for any resulting damage to property owners.

SPECIFICATIONS FOR A NEW DRAINAGE SYSTEM for New Orleans have been completed in revised form by Mr. L. W. Brown, City Engineer. An outline of the proposed drainage system was given in our issue of Nov. 8, 1894.

AN OPEN CUT OR A TUNNEL on Lexington Ave., New York city, through the steep hill which extends from 97th St. to 103d St., has been proposed by the Metropolitan Traction Co., whose cable cars have had a number of accidents at this point. The Department of Public Works has been consulted, and preliminary plans are being prepared for a tunnel wide enough for two car tracks and two carriage ways. The cost is estimated at about $700,000.

THE ELECTRIC POWER PLANT for supplying current for switching on the Brooklyn Bridge cable railway, is to be put in by the bridge trustees, on account of the high bids made by the electrical companies. The old lighting plant will be taken out and the new plant will be used for light and power. There will be a battery of boilers, three engines, three generators, and the motor equipment for 20 cars, so that there will be a motor car on each train. The system of switching trains by electric power was described in our issue of Feb. 13, 1896.

HORSELESS CARRIAGES are to be exhibited and given competitive trials at the Rhode Island State Fair, to be held at Providence, R. I., in September. The State Fair Association has offered $5,000 in prizes for the best machines.

THE STEEL BILLET POOL has not yet succeeded in increasing the demand for billets, consumers apparently delaying purchases in the hope that the pool prices will not be maintained, but other interesting results of the pool are coming to light. It is announced in a dispatch from Pittsburg that the Carnegie Steel Co. has purchased the entire allotment of the Ohio Steel Co., of Youngstown, O., and that the latter company will go out of business for the balance of the year, as far as making billets is concerned. The Carnegie Steel Co. is also said to be negotiating for the purchase of the allotments of other companies.

THE NEW PANAMA CANAL CO., of Paris., is said to have $10,000,000 available, and to intend to have an extensive series of borings made across the proposed route. A small preliminary canal 50 ft. wide is to be made at the site of the divide cut, and seven American cableways have been purchased for this work.

A 16-IN. COAST-DEFENCE GUN is provided for in the fortification bill and preparations are being made at Watervliet Arsenal for the building of this gun. As designed for the U. S. Navy, a 16-in. gun would be 46.6 ft. long, and weigh from 107 to 111½ tons. The powder charge would be about 1,000 lbs., the projectile would weigh 1,800 lbs., the muzzle velocity assumed is 2,100 ft. per second, imparting to the projectile a muzzle-energy of 61,114 ft. tons. The coast-defence gun may differ somewhat from these figures as the limitations are not the same as on board ship.

DITCHING CAR; ST. LOUIS SOUTHWESTERN RY.

On railways running through low-lying, damp and swampy districts, and having the grade line but little above the normal surface of the country, the question of drainage is a very important one in the maintenance of way work, and a considerable amount of money and labor must be expended in making and maintaining ditches in order to keep the roadbed and bank in proper condition. This is especially the case where the ballast is poor, and where the natural soil is used for ballast. A combination of the above conditions exists on a large mileage of railways in the Southwest, and there is consequently a good field for the application of ditching machines in order to expedite the work and reduce the cost for labor.

Cars for cleaning ditches and dressing the roadbed have been used by a number of railways, and are generally flat cars, fitted with derricks or cranes for handling scoops and mold boards or scrapers, but we illustrate this week what is probably the most complete and powerful ditching machine ever built. On the St. Louis Southwestern Ry. various devices of this kind were used with more or less success and economy, but it occurred to Mr. W. B. Doddridge, while General Manager of the road, that a good substantial machine could be designed which would enable railways to construct drainage ditches and build low embankments at a very small cost. In the first machine built (and now in service on the St. Louis, Iron Mountain & Southern Ry.) the apparatus was mounted on a wooden car, but it was found that while the operations were successful, the car was not strong enough to resist the severe strains to which it was subjected by the work of the plow, scraper, etc. A steel car was therefore designed, and the first complete machine and car was built in December, 1895, for the St. Louis Southwestern Ry. This is the machine shown in the accompanying illustrations.

The car is 46 ft. long, having plate girder sidesills, connected by angle iron transverse bracing. The end sills are heavy steel castings, and have extended curved ends to serve as attachments for the draft chains which pull the outer end of the scraper and the beam of the ditching scoop. At the middle of the car is a steel derrick post, 9 ft. high, seated in a frame below the floor and carrying a crane arm or jib having a reach of 14 ft. The crane can be turned through a complete circle. The car is carried on two four-wheel trucks, having diamond frames and the American Steel Foundry Co.'s cast steel bolsters.

One of the most interesting features of the machine is that all operations of the handling of the various parts are effected by means of compressed air. The air supply is stored in three cylindrical reservoirs, 22 ins. diameter and 10 ft. long, at a pressure of 80 lbs. per sq. in., and is supplied by the air-brake pump of the locomotive of the work train. These reservoirs are placed underneath the car, and there are also placed the following operating cylinders: One cylinder, 12 ins. diameter and 14 ft. 7 ins. long, for the derrick hoist; one cylinder, 12 ins. diameter and 9 ft. 5 ins. long, for swinging the derrick, the piston rod having a rack attachment for swinging the mast through a complete circle; four cylinders, 8 ins. diameter and 5 ft. 4½ ins. long, for the side guides. All the pistons are cushioned by air, and the cylinders take air pressure from either end. The various pipes are brought together to a "switchboard," mounted on the car, and all movements are controlled by cocks operated by a man standing at this switchboard, as shown in Fig. 1.

The main equipment of the car includes the following: (1) A solid cast steel plow, weighing 2,500 lbs., which cuts a furrow 20 ins. deep and 36 ins. wide; this is shown on the car in Fig. 1, and in operation in Fig. 5; (2) A triangular shaped scraper for cutting material for the embankment, as shown in Fig. 2; (3) A mold board for dressing the roadbed to the standard section, as shown in Figs. 3, 7 and 8; (4) A ditching scoop of 3 cu. yds. capacity, shown in Fig. 4. All these are operated by air from the car platform, being raised and lowered, guided as to lateral range, and loaded and unloaded by means of the derrick and the side-guide cylinders. The air appliances are all very simple, and very little labor is required to operate the car.

The general course of operation is as follows: The plow is first used to cut one or two furrows, as may be necessary to lower the ditch to the proper depth and furnish sufficient dirt to fill out the embankment to the standard section. The necessary beams, guides, etc., are so arranged that the plow is entirely under the control of the man handling the air; it can be set at any distance from the track that is desired, raised or lowered, or swung in or out to avoid obstructions too large to plow up. The nose of the plow is braced by a heavy bar attached to the side sill. The scraper is then used, as shown in Fig. 2, to bring the dirt from the ditch up toward the track. If the ditch is in a small cut, however, with banks not exceeding 5 or 6 ft. high, and the dirt is not required on the fill, the scraper can be reversed so as to remove the dirt from the ditch, throw it

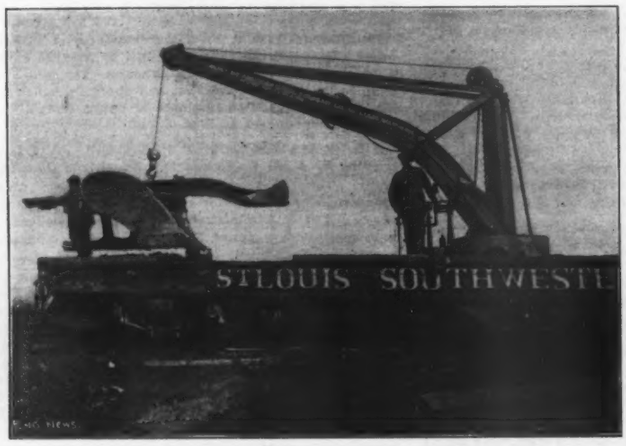

FIG. 1.—GENERAL VIEW OF DITCHING CAR OPERATED BY COMPRESSED AIR; ST. LOUIS SOUTHWESTERN RY.

W. B. Doddridge, Designer. American Steel Foundry Co., Builders.

FIG. 2.—DITCHING CAR WITH SCRAPER AT WORK.

FIG. 3.—DITCHING CAR WITH MOLD BOARD ATTACHED FOR DRESSING ROADBED SLOPES.

FIG. 4.—DITCHING CAR WITH EXCAVATOR OR DITCHING SCOOP ATTACHED.

outside and form a bank of even and regular surface.

The next tool used is the mold board or shoulder former, to dress up and finish the embankment. This tool extends from the ends of the ties at an angle of 30° with the car body, for a distance of 14 ft. As it is braced and held rigid with the car, the embankment is shaved perfectly smooth and exactly to template, no matter what is the elevation of the track. The template is of the form shown in Fig. 7, and is bolted to the lower edge of the mold board. Where the scraper has brought up too much dirt, the mold board removes it, carrying a sufficient quantity before it to fill up the low places where not enough dirt has been left. The tool is so shaped that it forms the shoulder on the top of the fill, reaches far enough to overlap the point at which the scraper left off, and leaves the embankment exactly shaped to the standard cross section of track shown in Fig. 8. The work done by this tool is by far the most interesting part of the proceeding. It can be readily adjusted as required, and can be raised easily to allow it to pass cattle guards, bridges, and road crossings. The track is then ready for ballasting.

The ditching scoop or excavator is an important part of the equipment, when ditching in deep cuts or preparing to lower track. It is attached to the car in the same way as the other tools, and is worked somewhat in the manner of a drag scraper or the dipper of a steam shovel. The dirt is scooped up and the car ran out on the embankment, where it is dumped. The whole operation is handled by air, the derrick raising and lowering the scoop, and tipping it to dump the load. With this tool, cuts can be excavated to any depth desired, from the ends of the ties out to a distance of 14 ft. The scraper and the scoop are attached by chains to a heavy steel beam, pivoted to the extension of the frame below the sills, and held in position by chains from the side and a rod from the end sill. The mold board is hauled directly by a chain attached to the end sill.

A cutting in which the track is being lowered 3 ft., is shown in Fig. 6, and the course of the ditching scoop is very evident, while Fig. 4 shows the scoop in use for ditching along a low level track. It has been found most convenient to work an entire day on one side of the track. When not delayed too much by passing trains there is no trouble in ditching and dressing up the embankments on one side of the track for a distance of 1½ to 2 miles per day, leaving a neat, well-drained and well-trimmed roadbed.

The force required to operate the outfit consists of the conductor of the work train (who acts as foreman of the work), two brakemen, one man to handle the air, and two laborers to make and change the various chain hitches. The entire cost of such labor is $18.30 per day. The locomotive propelling the machine moves at a rate of about four miles per hour, hence it is stated that the amount of work done in a day, at a total cost of about $30, would cost $500 to $1,000 if done by laborers. Besides this the embankment is left perfectly true to the standard section and in better shape than would be possible if the work was done by hand. The machine has been thoroughly tested on the St. Louis Southwestern Ry., near Pine Bluff, Ark., with most satisfactory results from a point of view of saving in labor, as well as of efficiency in work.

The machine was built by the American Steel Foundry Co., of St. Louis, Mo., under the patents of Mr. W. B. Doddridge, General Manager of the Missouri Pacific Ry. For the information and photographs used in this article we are indebted to Mr. Doddridge, to Mr. R. M. Galbraith, General Master Mechanic of the St. Louis Southwestern Ry., and to Mr. J. E. Boyce, his Chief Clerk. The photographs were all taken by Mr. A. F. Coons, an engineer employed on this railway.

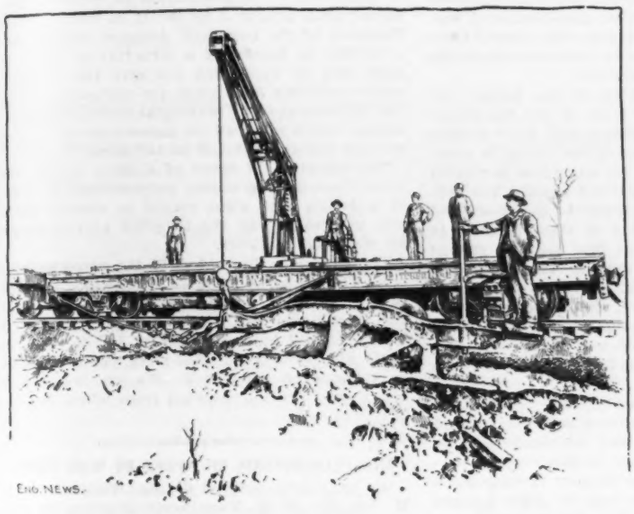

FIG. 5.—DITCHING PLOW AT WORK (Furrow, 20 Ins. Deep and 36 Ins. Wide).

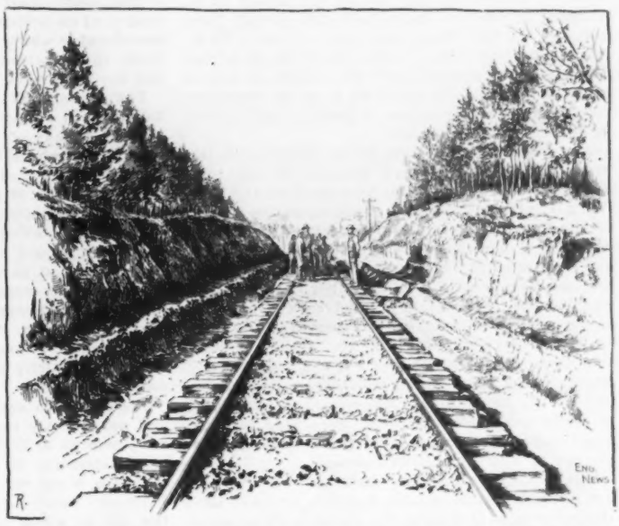

FIG. 6.—LOWERING SUB-GRADE 3 FT. IN A CUT BY THE DITCHING MACHINE.

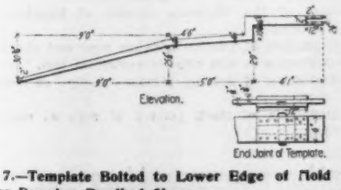

Fig. 7.—Template Bolted to Lower Edge of Mold Board for Dressing Roadbed Slopes.

FIG. 8.—CROSS SECTION OF ROADBED AS LEFT BY DITCHING MACHINE.

RAILWAY BRIDGES OF SHORT SPAN.

By F. W. Wilson, Jun. Am. Soc. C. E.

(With inset.)

Experience has proved that quite as serious results may be incurred by the failure of a short span bridge carrying railway traffic, as would ensue from the failure of a more pretentious structure, and as in general the short spans predominate, as to numbers, on most railways, they require a large percentage of the annual outlay for repairs and renewals. Such structures are, therefore, well worthy of the attention of the bridge engineer, and should be regularly inspected and carefully maintained even though of modest dimensions.

The lengths of structures particularly referred to in this article are those having clear spans of from 10 ft. to 30 ft. Openings having spans of less than 10 ft. can generally be made permanent to a degree at least, by building arch culverts of masonry or using pipe drains. As to arch culverts, however, there are often local circumstances which preclude their use, and they are not so permanent as might appear, unless built with care, and provided with the best of foundations.

Rail floor bridges of the type shown in Fig. 1 have been used on the New York Central R. R. for some years past, and have given the most satisfactory results for spans of from 8 ft. to 16 ft. in the clear. The bridge inspector reports that under the passage of trains there does not appear to be the slightest deflection or disturbance, even on bridges spanning openings of 15 ft. The weights of the styles of construction shown in Fig. 1 are given in the accompanying table.

Weights of Rail Floor Bridges.

Plan.	Clear Span.	Total Length.	—Four Tracks.— Wt per sq. ft.	Wt per lin. ft.	Total Wt.	—Two Tracks.— Wt per sq. ft.	Wt per lin. ft.	Total Wt.
	ft.	ft.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	8	11	50.38	2,620	28,820	50.7	1,420	15,620
No. 1	10	13	54.61	2,840	36,920	54.64	1,530	19,890
No. 2	10	13	62.70	3,260	42,380	62.14	1,740	22,620
No. 1	12	15	66.15	3,440	51,600	65.35	1,830	27,450
No. 2	12	15	75.00	3,900	58,500	73.57	2,060	30,900
	13	16	70.00	3,640	58,240	68.93	1,930	30,880
	14	17	73.85	3,840	65,280	74.28	2,080	35,360
	15	18	83.46	4,340	78,120	81.43	2,280	41,040
	16	19	91.15	4,740	90,060	88.57	2,480	47,120

One of the principal features of a rail-floor bridge, which commends it for railway purposes in general, is that all the work can be done by the road department forces, and hence no contracts or special appropriations are necessary to their construction. In this manner old rails which have been abandoned for heavier sections can be utilized to the best possible advantage. There is, however, the objection that if the execution of such work is left entirely in the hands of the road department forces, without inspection of any kind, it may sometimes lead to the use of a less number of rails than is called for on the plans, in case they do not happen to have the requisite number of rails on hand.

The rails should be given a preservative coating of some kind, applied hot. Immersion in a bath composed of 10 parts of Trinidad asphalt and 30 parts of coal tar pitch, heated to 350° F., would

no doubt be as effective as any. In order to do this, however, a tank for immersing the rails would become necessary, and, if this plan is followed, the old rails for use of this kind should be stored at some of the company's shops, where a tank containing the composition would be maintained. Then, upon a requisition from the road department, the rails could be sawed off to the required lengths, dipped in the tank, and then forwarded to the site of the bridge. The sawing of the rails in the shops would effect a considerable saving in he expense of the work, as the labor involved in cutting them at the bridge site is necessarily considerable.

The use of rail-floor bridges is not to be recommended for clear spans of more than 12 ft., if 65-lb. rails are used. If 80-lb. rails are used, then the maximum span should not exceed 14 ft. Bridges of this type have, as before stated, been used on the New York Central R. R. up to 15 ft. clear span, but owing to the slight depth of the rails, when compared with this length, I do not think it advisable to continue to do so, although the physical performance of spans of this length is all that could be desired.

For spans ranging from 14 ft. to 28 ft., in the clear, longitudinal trough bridges, of the type shown in Fig. 2, have also been used on the New York Central R. R. for a considerable period. While this type of bridge offers several important advantages, yet these are almost or quite offset by the serious consideration that they are not easily inspected or painted. To do either or both with any degree of frequency involves considerable expense, since it involves the removal of the ballast. Further than this, the temptation to neglect those things which are not apparent superficially is a serious one to most bridge inspectors, and the result is that a bridge so difficult of access is likely to be left untouched from year to year until rusted to such an extent as to endanger its efficiency, and demand its renewal.

The same inaccessibility may also be charged against a rail-floor bridge, but this at least has the advantage of having the metal work in more compact masses, and the loss of section from rust would proceed more slowly than in the case of plates and angles, such as are used in the construction of longitudinal trough spans.

Both of the foregoing types possess one great advantage, which is that the ballasted track may be so perfectly surfaced in conjunction with the track approaching the bridge that no shock is felt in crossing, or in the change from the solid roadbed to the bridge floor.

The writer has given this subject serious consideration in connection with his routine duties, and has recently designed a type of short-span bridge for use on the New York Central R. R., which would seem to have some advantages over either the rail-floor or the longitudinal trough bridge. This plan is shown in Fig. 3, arranged for a double-track span of about 17 ft. total length. The track support is essentially made up of four I-beams to each track, these being so spaced that all are equally loaded. A sway frame near each end holds the I-beams in position. Across the tops of these main beams are laid 7-in. I-beams spaced about 14 ins. c. to c., and running transversely the full width of the bridge. Over these beams a 5-16-in. plate is riveted, being spliced as frequently as desired in the length of the bridge. The rail is supported upon tie-plates which rest in a continuous channel lying upon the 5-16-in. plate.

The rail connection is shown in detail in Fig. 4, and this method of securing the track rails direct to the metal flooring is in some respects novel. The bolts used are straight instead of curved as they have heretofore usually been made, and the two beveled washers hold the rail securely in place; but when the nuts are loosened the rail may be moved laterally ½ in. in either direction, owing to the slotted hole in the lower washer. The rail is cushioned upon a sheet of indurated fiber ¼ in. thick, and two clips of fiber ⅛ in. thick, one on each side, are placed between the washer and the rail. By means of a very simple interlocking of the bottom sheet of fiber, the two side pieces of fiber and the two lower washers, all of the five pieces are secured by the two bolts.

The introduction of the fiber is primarily to form a cushion for the rail, and to deaden the noise, but, as shown in the details, it also serves as a complete insulation for the rail, which becomes a necessity where the rails are used for conducting electric currents in the operation of automatic signal systems.

The longitudinal beams are provided with sole plates, at their ends, and rest upon creosoted timber blocking which assists in providing some elasticity to the bridge, and also assists in distributing the loads upon the masonry.

The girders at the sides of the bridge are intended to support the ends of the transverse beams in case of derailment, and they project about 6 ins. above the floor of the bridge in order to serve as a guard rail. An angle iron is riveted along the sides of the floor and against the outside girders, partly as a finish to the floor, and partly to reinforce the top of these girders, in case they should be called into play as guards for a derailed car. By making the transverse beams of such section that the strain per square inch will be tolerably high, the deflection of the portion between the longitudinal supporting beams might be made sufficient to about represent the elasticity to be had if wooden ties were used.

These bridges can be easily inspected, cleaned and painted, are easily shipped and erected, and are cheap as to first cost and maintenance. One of the elements of economy in this type of construction is the very small amount of shop work required. Some objections may be urged against the use of rolled beams, but the writer thinks that it would be better to take the difference in cost of rolled beams and built beams and apply it to securing heavier sections of the rolled beams. Using as a standard of comparison, a span of 17 ft. total length, double track, the cost for a bridge of this type complete will be about $1.48 per sq. ft. of floor area, while the cost for a longitudinal trough span of same capacity and dimensions would be about $2.05 per sq. ft. at present prices. This difference represents a total of $270 for a single span of these dimensions. Where there are numbers of such spans, as is the case on the New York Central R. R., this saving is of cosiderable consequence. Then, again, the depth from base of rail to the lowest part of a structure is often a matter of importance, and a saving of from 3 to 5 ins. in this depth can be made by using the I-beam construction above described instead of the longitudinal troughs.

THE NEW TENNESSEE RIVER BRIDGE AT KNOXVILLE, TENN,

The growing tendency in this country toward the adoption of aesthetic designs for important city bridges has been illustrated recently by the adoption of Melan concrete arch structures for bridges at Topeka, Kan., and Paterson, N. J. Another excellent example of the public demand for something more than mere stability and safety is the selection of designs for a bridge over the Tennessee River at Knoxville, Tenn. This bridge is to be located at Gay St., and the site is one admirably suited to a structure of noble architectural design. It was at first proposed to build a stone arch structure, using the beautiful Tennessee marble, which occurs in abundance in the vicinity. One design for such a structure employed four spans of 240 ft. each, so that each span would have exceeded by 20 ft. the length of the greatest stone arch in existence (the Cabin John bridge at Washington, D. C.). Another design contemplated a single large span arch, flanked by 150 ft. spans on each side. Estimates were secured for a structure of this latter style built either in stone or of Melan concrete construction, which indicated that the cost would be in the neighborhood of a half-million dollars, and the project for a masonry structure was therefore reluctantly abandoned.

Bids were also received at about the same date for a steel truss bridge with straight deck and a wood floor. The Youngstown Bridge Co., of Youngstown, O., in submitting its estimate, presented plans prepared by Mr. C. E. Fowler, Chief Engineer of the company, designed with a view of giving as handsome a structure as could be built out of steel, and yet give the necessary water way and head room for navigation. This was accomplished by making an arched cantilever design, which gives all the appearance of an arch without the great thrust on the piers.

The agitation in favor of a stone bridge had given the public a strong prepossession in favor of a design with some claims to artistic merit, and the result was the adoption of this design by the County Court.

The design is illustrated in the accompanying cut. The bridge is to be 42 ft. in width over all, carrying a 30-ft. paved roadway with two street car tracks and two 6-ft. sidewalks. The north abutment will have a length of 127 ft., and the south abutment 60 ft. The piers will in all cases be founded on solid rock. We are indebted to Mr. Fowler for the drawing from which our cut is reproduced.

THE ADOPTED DESIGN FOR THE GAY ST. BRIDGE OVER THE TENNESSEE RIVER, KNOXVILLE, TENN.
[Prepared by C. E. Fowler, Assoc. M. Am. Soc. C. E., Chief Engineer, Youngstown Bridge Co.

THE TRANSMISSION OF POWER BY WIRE ROPES.

We have been favored by Mr. William Hewitt, M. Am. Soc. M. E., Vice-President of the Trenton Iron Co., Trenton, N. J., with a copy of a recent mathematical investigation made by him of the horse power that may be transmitted by wire ropes of iron or steel. His analysis differs from that given by earlier writers in considering that the resistance to bending of a wire laid in a rope and wound around a sheave is not the same as that of bending a single wire in a plane around a sheave of the same diameter. Since the wire in a rope is not a simple curve in one plane, but a spiral bent into a curved form, the resistance to bending, according to Mr. Hewitt, is very much less than that of bending the straight wire. Without taking space for the details of Mr. Hewitt's computations, we give below an abstract showing the results reached by him:

Notation.

D =Diameter of the rope in inches.
d =Diameter of the individual wires.
E =Modulus of elasticity=28,500,000.
e =Base of the Naperian system of logarithms=2.7182818.
f =Coefficient of friction between rope and sheaves.
h =Deflection of still rope at centre, in feet.
h_1=Deflection of driving portion of rope at center in feet.
h_2=Deflection of slack portion of rope at center, in feet.
K =Force transmitted.
k =Elastic limit per sq. in. of wire section.
k_1=Stress per sq. in. of wire section due to s_1=k—k_2.
k_2=Stress per sq. in. of wire section due to bending around sheaves.
N_G=Gross horse power transmitted.
N =Actual horse power transmitted.
N_1=Loss of horse power due to centrifugal force.
N_2=Loss of horse power due to journal friction.
n =Number of half laps of rope.
R =Radius of terminal sheaves, in inches.

S = Span between axes of sheaves, in feet.
s = Tension of rope at rest.
s_1 = Tension of driving portion of rope.
s_2 = Tension of slack portion of rope.
v = Velocity of rope in ft. per second.
W = Total weight of rope, in lbs.
w = Weight of terminal sheaves and shafts.
w_1 = Weight of intermediate rollers and axles.
x = Ratio of radius of sheaves to diameter of wires.

The formulas for determining the tensions of the rope are as follows (Weisbach, Vol. III., p. 237):

$$s_1 = \frac{e^{f n \pi} K}{e^{f n \pi} - 1}$$

$$s_2 = \frac{K}{e^{f n \pi} - 1}$$

$$\text{and } s = \frac{s_1 + s_2}{2}$$

If we represent by a the coefficient $\frac{e^{f n \pi}}{e^{f n \pi} - 1}$ we have for the gross horse power transmitted:

$$N_o = 0.000714\ D^2 v \frac{28500 - k_2}{a}, \text{ for iron rope.}$$

$$N_o = 0.000714 D^2 v \frac{57000 - k_2}{a}, \text{ for steel rope.}$$

These two formulas contain two variable factors, a and k_2, the former depending on the character of the terminal sheaves, the kind of filling used, and the number of half laps which the rope makes; and the latter on the size of the terminal sheaves. For drums or sheaves with plain grooves we have $f = 0.18$, for wood-lined sheaves $f = 0.23$ and for sheaves filled with rubber and leather $f = 0.4$. The corresponding values of a for one up to six half laps of the rope are given in Table I.

TABLE I.—Values of a in above Formulas.
n = number of half laps on driving wheel.

f	1	2	3	4	5	6
0.18	2.316	1.476	1.224	1.116	1.069	1.035
0.23	1.943	1.309	1.129	1.060	1.027	1.013
0.40	1.400	1.088	1.024	1.007	1.002	1.0005

For given values of E, R and d the different values of k_2 (the stress due to bending) for the different kinds of ropes of the ordinary lay, are slight. An average value is:

$$k_2 = \frac{E}{2.06\,x + 36}$$

From this value of k_2, and from the value of s_1 given above are derived the figures in Table II.

TABLE II.—Stresses in Wire Rope due to Tension and to Bending.

Ratio of diameter of sheave to diam. of wire.	Stress per square inch of wire section. Due to tension of the driving part of rope. Iron rope.	Steel rope.	Due to bending around sheaves. Iron rope.	Steel rope.
324	....	16,500	....	40,500
345.6	....	19,000	....	38,000
360	....	20,500	....	36,480
384	....	22,800	....	34,200
432	....	26,220	....	30,780
460.8	....	28,500	....	28,500
480	850	29,350	27,650	27,650
504	2,000	30,500	26,500	26,500
518.4	2,560	31,060	25,940	25,940
540	3,700	32,200	24,800	24,800
576	4,130	33,630	23,370	23,370
600	5,270	34,770	22,230	22,230
604.8	5,300	34,800	22,200	22,200
648	7,700	36,200	20,800	20,800
672	8,550	37,050	19,950	19,950
691.2	9,120	37,620	19,380	19,380
720	9,500	38,000	19,000	19,000
756	10,450	39,040	17,960	17,960
768	10,830	39,330	17,670	17,670
777.6	11,110	39,610	17,390	17,390
792	11,400	39,900	17,100	17,100
806.4	11,680	40,180	16,820	16,820
840	12,540	41,040	15,960	15,960
864	12,820	41,320	15,680	15,680

It appears from the equations (not here given) that a certain ratio exists between d, the diameter of the individual wires, and R, the radius of the terminal sheaves, which will give a maximum value to N_o, the gross horse-power transmitted, and that this occurs when the factor $\frac{k_1}{x^2} = \frac{k - k_2}{x^2}$ is a maximum. This also corresponds to a minimum value of R. Solving for a maximum we obtain

x = 720 for iron rope
x = 345.6 " steel "

from which we obtain the figures given in Table III.

TABLE III.—Minimum Diameters of Sheaves for Wire Rope Transmission.

Diam. of Rope.	Iron Rope. 7 wire.	12 wire.	19 wire.	Steel Rope. 7 wire.	12 wire.	19 wire.
	Ratio of Radius of Sheave to Diameter of Wires.					
¼	40	30	24	19	14	12
5-16	50	38	30	24	18	14
⅜	60	45	36	29	22	17
7-16	70	53	42	34	25	20
½	80	60	48	38	29	23
9-16	90	68	54	43	32	26
⅝	100	75	60	48	36	29
11-16	110	83	66	53	40	32
¾	120	90	72	58	43	35
⅞	140	105	84	67	50	40
1	160	120	96	77	57	46

Substituting the values of x in the equation we find approximately $k_1 = \frac{1}{75} k = 9{,}500$ for iron and 19,000 for steel, and the bending stress, therefore, even under these favorable conditions is double the transmitting force. We find by substitution in the formula, for the gross horse-power transmitted.

$$N_o = 6{,}783 \frac{D^2 v}{a} \text{ for iron rope.}$$

$$N_o = 13{,}566 \frac{D^2 v}{a} \text{ for steel rope.}$$

Iontha of the entire weight of all the moving parts multiplied by the speed of the rope in feet per second, or

$$N_2 = .000006\ (W + w + w_1)\ v.$$

The loss will be less for steel than for iron on account of the smaller sheaves which may be used. For flying transmissions of a single span $w_1 = 0$. Table V. gives the values of N_2 for different speeds corresponding to the sizes of sheaves commonly employed, with the values of W + w, taking for W the largest rope on a 300-ft. span.

TABLE V.—Loss of Horse Power due to Journal Friction on Single Spans.

2R* W + w v = Speed of Rope i nFeet per Second.

ins	lbs.	10	20	30	40	50	60	70	80	90	100
18	300	.02	.04	.05	.07	.09	.11	.13	.14	.16	.18
24	500	.03	.06	.09	.12	.15	.18	.21	.24	.27	.30
30	800	.05	.10	.14	.19	.24	.29	.34	.38	.43	.48
36	1,150	.07	.14	.21	.28	.33	.41	.48	.55	.62	.69
42	1,500	.09	.18	.27	.36	.45	.54	.63	.72	.81	.90
48	2,000	.12	.24	.36	.48	.60	.72	.84	.96	1.08	1.20
60	2,500	.15	.30	.45	.60	.75	.90	1.05	1.20	1.35	1.50
72	3,100	.18	.37	.56	.74	.93	1.12	1.30	1.49	1.67	1.86
84	3,800	.23	.46	.68	.91	1.14	1.37	1.60	1.82	2.05	2.28
96	4,500	.27	.54	.81	1.08	1.35	1.62	1.89	2.16	2.43	2.70
108	5,900	.35	.70	1.06	1.42	1.77	2.12	2.48	2.83	3.19	3.54
120	7,300	.44	.88	1.31	1.75	2.19	2.63	3.07	3.50	3.94	4.38

*2R = diameter of sheave in inches.
W + w = weight of rope and sheave, in lbs.

TABLE VI.—Horse Power Transmitted by Iron or Steel Ropes of Different Sizes at Various Velocities, and on Sheaves with Wood Filling and with Rubber and Leather Filling.

	Diam. of rope, ins.	Velocity of rope, ft. per second. 10	20	30	40	50	60	70	80	90	100
		Horse power transmitted.									
Iron ropes on wood filling.	¼	2	4	6	8	10	12	13	15	17	18
	5-16	3	6	10	13	16	19	21	24	26	28
	⅜	5	9	14	19	23	27	31	34	35	41
	7-16	7	13	19	25	31	36	42	47	51	56
	½	9	17	25	33	40	48	55	61	67	73
	9-16	11	21	32	42	51	61	70	78	85	92
	⅝	13	26	39	51	63	75	86	96	105	114
	11-16	16	31	47	62	76	90	104	116	128	138
	¾	19	37	56	74	91	108	124	138	139	164
	⅞	26	51	76	100	124	147	168	188	207	224
	1	34	67	99	130	162	192	220	246	270	292
Steel ropes on wood filling.	¼	4	8	13	17	21	25	28	32	37	40
	5-16	7	13	20	26	33	40	44	51	57	62
	⅜	10	19	28	38	47	56	64	73	80	80
	7-16	13	26	38	51	63	75	88	99	109	121
	½	17	34	51	67	83	99	115	130	144	159
	9-16	22	43	65	86	106	128	147	167	184	203
	⅝	27	53	79	104	150	155	179	203	225	247
	11-16	32	63	95	126	157	186	217	245	272	299
	¾	38	76	103	150	186	223	258	290	321	355
	⅞	52	104	156	206	257	306	354	400	446	489
	1	68	135	202	268	333	397	460	520	578	634
Iron ropes on rubber or leather filling.	¼	3	6	9	12	14	17	19	22	24	26
	5-16	5	9	14	18	23	27	31	34	38	41
	⅜	7	13	20	26	32	38	44	40	54	58
	7-16	9	18	27	36	44	52	60	67	73	79
	½	12	24	35	47	58	68	78	88	97	104
	9-16	15	31	46	60	74	88	101	113	124	134
	⅝	19	37	55	73	91	97	123	138	151	163
	11-16	23	45	67	88	109	129	148	166	182	197
	¾	27	53	80	105	130	154	177	198	217	235
	⅞	37	74	110	145	179	212	243	272	299	323
	1	48	96	142	188	233	275	316	353	388	420
Steel ropes on rubber or leather filling.	¼	6	12	18	24	29	35	41	46	51	56
	5-16	9	19	28	38	47	56	64	73	81	89
	⅜	13	27	40	54	67	79	92	104	116	127
	7-16	18	37	55	73	90	108	125	141	157	172
	½	24	48	72	96	119	142	164	186	207	227
	9-16	31	62	92	123	152	182	210	238	265	289
	⅝	37	75	113	149	186	221	256	290	322	354
	11-16	45	91	136	180	224	267	308	349	388	426
	¾	54	108	162	215	267	318	368	416	463	508
	⅞	74	149	222	295	367	437	505	572	636	698
	1	96	193	289	383	476	568	657	743	827	907

The above figures give the amount of power transmitted under maximum safe working tensions, corresponding to deflections as given by the formulas for deflections and the minimum sheaves, as given in Table 3. It is well, therefore, to make some allowance for the stretching of the rope, and to advocate somewhat heavier equipments than given by these tables; that is, if it is desired to transmit 20 HP. to put in a plant that would transmit 25 to 30 HP., thus avoiding the necessity of having to take up a comparatively slight amount of stretch in the rope. Rubber and leather lined sheaves are generally used for the transmission of power, and with such sheaves Mr. Hewitt's custom has been, in laying out a plant, to use the figures in the table for wood lined sheaves, so as to be on the safe side.

For the loss due to centrifugal force we have

$$N_1 = 0.0000847 \frac{D^2 V^2}{a}$$

TABLE IV. Values of a N_1 corresponding to different values of D and v in the formula $N_1 = 0.0000847 \frac{D^2 V^2}{a}$

Diam. of Rope. ins.	Velocity of Rope in Feet per Second. 10	20	30	40	50	60	70	80	90	100
¼	..	.04	.14	.34	.66	1.14	1.82	2.41	2.90	5.29
5-16	.01	.06	.22	.53	1.03	1.79	2.84	4.23	6.03	8.27
⅜	.01	.10	.32	.76	1.49	2.57	4.08	6.10	8.68	11.91
7-16	.02	.13	.43	1.03	2.03	3.50	5.56	8.30	11.82	16.21
½	.02	.17	.57	1.35	2.65	4.57	7.26	10.84	15.44	21.17
9-16	.03	.22	.73	1.71	3.35	5.79	9.19	13.72	19.54	26.80
⅝	.03	.26	.89	2.11	4.14	7.15	11.35	16.94	24.12	33.09
11-16	.04	.32	1.08	2.56	5.00	8.65	13.73	20.50	29.18	40.03
¾	.05	.38	1.30	3.04	5.95	10.29	13.84	24.39	34.73	47.64
⅞	.07	.52	1.76	4.14	8.11	14.01	22.24	33.20	47.27	64.85
1	.09	.68	2.30	5.41	10.59	18.30	29.05	43.37	61.75	84.70

The loss of power due to journal friction varies directly as the pressure on the bearings, due to the stresses in the rope, and to the weight of the moving parts. It is approximately six mill-

Combining all the quantities, we have for the general formula for the actual horse power transmitted

$$N = \left[(.000714\ k_1 - .0000847\ v^2) \frac{D^2}{a} - .000006\ (W + w + w_1) \right] v$$

For flying transmissions, in which $w_1 = 0$, and in which the rope makes but a single half wrap on the driving sheave, taking $a = 2$ for wood-lined sheaves and $a = 1.4$ for sheaves lined with rubber and leather, we obtain the values for amounts of horse power transmitted given in Table VI.

In order to give the proper tensions to the rope we must know the deflections corresponding to these tensions. For flying transmissions, in which $n = 1$, we have the following:

Formulas for Deflections of Flying Ropes.
S = span in ft., h_1 = deflection of driving rope at center in ft.
h_2 = " " slack " " "
h = " " still " " "

		Iron rope.	Steel rope.
For wood-lined sheaves, f = 0.235	h_1 =	.00005 S^2	.000025 S^2
	h_2 =	.0001 S^2	.00005 S^2
	h =	.000075 S^2	.0000875 S^2
For rubber-lined sheaves, f = 0.4	h_1 =	.00005 S^2	.000025 S^2
	h_2 =	.000175 S^2	.0000875 S^2
	h =	.000085 S^2	.00004 S^2

TABLE VII.—Table of Deflections.

Span in feet	100	150	200	250	300	350	400
Deflection of rope at center, in feet, when not running.							
Iron rope on wood filling	.750	1.687	3.00	4.687	6.750	9.187	12.00
Steel " " " "	.375	.843	1.50	2.343	3.375	4.593	6.00
Iron " " rubber "	.800	1.800	3.20	5.000	7.200	9.800	12.80
Steel " " " "	.400	.900	1 60	2.500	3.600	4.900	6.40

THE FOLSOM-SACRAMENTO ELECTRIC POWER TRANSMISSION PLANT.

The completion of the power transmission scheme between Folsom and Sacramento, Cal., is the conclusion of a vast enterprise, undertaken in doubt and terminated in a success which has demonstrated not only the tremendous resources of power in the State of California, but also the commercial feasibility of electrical transmission over long distances. A sketch of the progress of the work, including a view of the dam at Folsom, was given in our issue of April 11, 1895. In what follows we give an account of the electric plant in somewhat greater detail.

Fig. 1.—Penstocks of the Four Turbine Wheels at the Folsom, Cal., Power Plant.

The hydraulic apparatus, manufactured by S. Morgan Smith, of York, Pa., consists of four pairs of 30-in. wheels of the McCormick horizontal shaft turbine type, each pair of 1,260 HP. capacity at 300 revolutions operating under a head of 55 ft. The steel penstocks are 8 ft. in diameter, and each wheel has two draft tubes. The governors are of the Faesch-Picard type, and these are assisted by heavy fly wheels fitted to the water wheel shafts. The hydraulic plant also includes two special horizontal wheels for the exciters.

The power house is a two-story brick building. As shown in Fig. 1, the water wheels are placed in the open air between the forebay and the wall of the structure, through which the turbine shafts pass. To each shaft is coupled a 750-K-W. (1,000-HP.) General Electric three-phase generator, the largest of their type yet constructed, shown in Fig. 2. Each is a 24-pole machine delivering current at 60 cycles, 800 volts and running at 300 revs. per min. The exciters are 4-pole, 500-volt, 30 K-W. generators, either one of which is of sufficient capacity to excite the fields of all four generators. From the generators the current passes to the generator switchboard, and thence to nine step-up transformers, each of 250-K-W. capacity in the upper story of the power house. The transformers are cooled by an air blast from blowers driven by induction motors. In these transformers the pressure is raised from 800 to 11,000 volts, and from them the current passes to the high-tension transmission lines.

The switchboards are of Tennessee marble, and are so arranged that the generators may be run in parallel or on separate lines, as may be desired. The generator switchboard carries the necessary switches, instruments and other apparatus for synchronising the generators. The boards in the transformer room carry switches for the high and low tension sides of the transformers and switches and current indicators for the transmission lines.

The pole line is double throughout, and follows the highway from Folsom to Sacramento, a distance of 24 miles. Each pole carries two cross-arms for two circuits, each circuit consisting of three bare copper wires supported on double petticoated porcelain insulators, especially designed and made for this installation at the porcelain factory of the General Electric Co., at Schenectady. Each insulator before shipment was exposed to a test of not less than 25,000 volts alternating. Each circuit can carry the output of one dynamo, and any dynamo can be thrown on any line. The line loss is calculated at 7.5% when transmitting 3,000 HP.

The telephone line is carried on the same poles as the transmission line and connects the power house with the sub-station in Sacramento. The transmission lines being spiralled every mile, and the telephone wire transposed every fifth pole, no induction is noticeable on the telephone circuits, and conversation is not in any way interfered with.

The sub-station is a fireproof two-story brick building on the corner of Sixth and H Sts., Sacramento, having the transformers on the second floor and the dynamo room on the ground floor. In the transformer room the high-tension switchboards receive the terminals of the 10,000-volt lines and operate the different combinations of the step-down transformers. These transformers, 21 in number, 15 of 125 K-W. and 6 of 40 K-W. capacity, vary in size, according to the duty required of them, the secondaries delivering current at 125, 500 and 1,000 volts. They are also ventilated by blowers.

The transformers are connected to high and low-tension switches on the boards, and from these the current passes to the distributing boards for the synchronous motors, power circuits and incandescent lighting.

In the main or dynamo room of the sub-station, shown in Fig. 3, a line shaft runs the entire length. To this are directly coupled, through friction clutches, three synchronous motors, each of 250 K-W. capacity, wound for a potential of 500 volts and run at a speed of 450 revolutions. To the line shaft are belted one 200-K-W. and one 90-K-W. multipolar G. E. railway generators and two 100-K-W. Edison bipolar machines, all of 500 volts, and three 100-light and two 75-light Brush arc machines. In this room are also the switchboards for controlling the synchronous motors, the railway generators and circuits and the arc dynamos.

For the operation of the synchronous motors 750 K-W. of transformer capacity is utilized, the balance being used for low and high-tension distribution. The low-tension current is distributed by a three-phase, four-wire system, combining the three-phase and Edison three-wire system—i. e., three wires for the three-phase current and a fourth or neutral wire. Incandescent lights are connected between the neutral and any one of the three other wires, while motors are connected to the three-phase wires, giving at the mains 115 volts for lamps and 200 volts for motors. The feeders for this extensive system pass from the sub-station through a distributing switchboard which carries potential regulators for maintaining constant pressure at the mains. Additional circuits run from the sub-station at 500 and 1,000 volts, supplying current for lights and motors in the more distant parts of the city.

Power was transmitted for the first time from Folsom to Sacramento on July 14, 1895, for the operation of the Sacramento Street Ry. On Sept. 9 a grand carnival was held to celebrate what up to the present is the longest commercial power transmission ever effected. The balance of the machinery has since been set up, and the installation is now complete.

The power transmitted is now being used for manufacturing purposes as well as for lighting the city and running the street railway. The power is much cheaper than generated by steam, and it is interesting to note that the steam engine is fast disappearing from Sacramento factories. Among the establishments now using the power are flour mills, box factories, machine shops and hotels.

The largest consumer is the street railway, which has over 24½ miles of single and 17 miles of double track, and operates 32 motor cars and trailers. The Southern Pacific Ry. shops employ a large number of motors for drawbridges and elevators in freight sheds. The Buffalo Brewing Co. is about to install five non-synchronous motors to replace steam engines which have been in use for years, and expect to save 40% of the present cost of operation by the change.

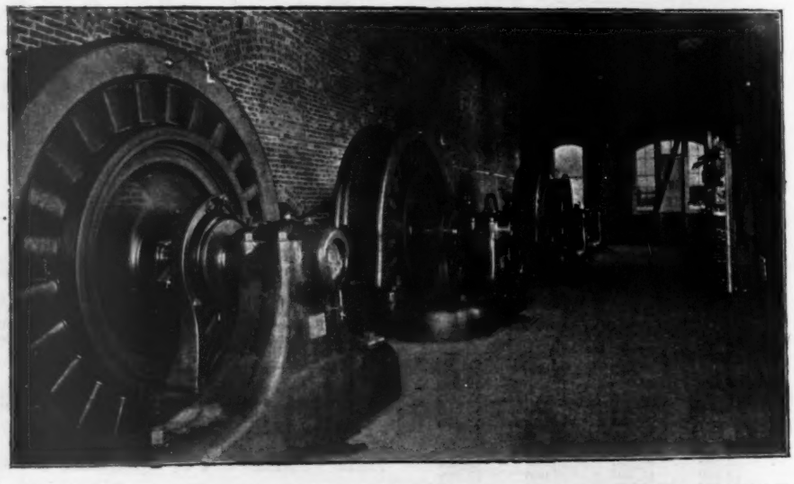

FIG. 2.—GENERATOR ROOM AT FOLSOM, CAL., OF THE FOLSOM-SACRAMENTO ELECTRIC TRANSMISSION PLANT.

The entire equipment was carried out by the General Electric Co., whose apparatus is exclusively employed. This plant is a complete illustration of the possibilities of electric transmission, every problem to be met with in transmitting power over long distances at high potentials and utilizing it having been solved successfully. The best indication of this success is reflected in the value of the interest-paying obligations, the bonds of the Sacramento Electric Light & Power Co. finding ready purchasers at par, although the plant has been in operation less than one year.

REPORT ON MUNICIPAL OWNERSHIP OF ELECTRIC STREET LIGHTING PLANT FOR UTICA, N. Y.

Those interested in the question of municipal ownership of lighting plants may glean some items from a report on electric street lighting made by a committee of the Common Council of Utica, N. Y. Mr. Chapman L. Johnson, City Surveyor, was chairman of the committee, and Mr. Montgomery H. Johnson was selected as electrical engineer.

The report contains a detailed estimate, by Mr. M. H. Johnson, of the cost of installing and operating 450 arc street lamps of 2,000 c. p. each, the generating plant to be capable of supplying 500 lamps. The cost of construction is estimated

FIG. 3.—DYNAMO ROOM AT THE SACRAMENTO SUB-STATION OF THE FOLSOM-SACRAMENTO ELECTRIC TRANSMISSION PLANT.

at $161,441, including $15,500 for underground conduits in a few business streets and $1,000 for an extra engine for other purposes. Operating expenses for the 450 lamps are estimated at $29,288. Interest on the whole cost is allowed at 4% and depreciation is reckoned at 5% for the steam plant, 3% for the buildings and subway conduits and 10% for electrical apparatus and line. This makes a total annual outlay of $44,906, or about $100 per lamp per year.

The estimates are based on 4,000 lamp-hours, or 10.9 hours per night, against 3,650, or 10 per night, now furnished by a private company at $126.83 per lamp.

By adding to Mr. Johnson's figures a yearly sum for sinking fund, which he very properly omitted, having already allowed for depreciation by increasing his estimates for labor at some points on its own account, and for labor, coal and interest on the strength of estimates of operation and first cost made by the Utica Association of Stationary Engineers, the committee arrives at $127.70 as the cost per lamp per year, in place of $100. Or, without recourse to the figures of the Stationary Engineers, the committee, by retaining its addition for sinking fund and labor, and increasing Mr. Johnson's coal allowance from 2½ to 3½ lbs. per HP.-H., the cost per lamp is raised to $120.16.

The sum allowed by the committee for sinking fund was $4,844. Strangely enough, in its search for items to increase Mr. Johnson's estimate, the committee overlooked depreciation on the $24,000 additional cost allowed by them. This extra cost was on the steam plant, for which Mr. Johnson allowed 5% depreciation, which would amount to $1,200. Deducting this from the committee's allowance for sinking fund, there would still remain $4,644, or over $10 per lamp, incorrectly added by the committee to Mr. Johnson's estimates, bringing the committee's revised figures down to $117.70, or $110.16, respectively, for its figures alone, or these combined with those of the Stationary Engineers.

The committee had before it an estimate of $80 per lamp per year, under municipal ownership, made by Mr. E. P. Roberts, and apparently urged by the Utica Trades Assembly. It also had a statement of the detailed operating expenses of the plant of the Utica Electric Light Co. for 1894 and 1895, which is published in the report. This statement shows a fuel account for 1895 nearly double the estimate made by the Stationary Engineers and nearly three times that made by Mr. Johnson. The company's item of "interest paid" was $13,561 in 1894 and $11,512 in 1895. At 6% the interest charge for 1895 would indicate a capital account of nearly $200,000. If the company is paying a higher rate of interest, this fact only increases the argument for municipal ownership.

as at 4% interest, the rate allowed by Mr. Johnson and accepted by the committee, $11,512 would pay interest on nearly $300,000.

The committee reviews the experience of other cities with municipal lighting plants and after quite a discussion of the subject concludes that the service can be secured quite as cheaply by private contract. It therefore recommends that bids be invited for lighting the street for periods of one, two and three years, and while speaking of "open and free competition," calls attention

to the fact that the award of a contract to a new company would mean not only the destruction of the investment made by our own citizens in establishing the existing plant, but would also disfigure and injure such of our principal streets as may not be provided with subways, by the multiplication of poles and wires.

The above quotation brings up a point emphasized by Mr. Johnson in discussing the cost of lighting under private contract. The shortness of most of these contracts makes high prices necessary, since the contractor must obtain not only the cost of operating his plant, but a sum in excess to make up for the risk of having a large part of his plant rendered useless by a failure to secure the renewal of the contract.

The Utica Electric Light Co. has already offered to furnish street lamps at $120.45 each for 3,650 hours per year, under a ten-year contract. Mr. M. H. Johnson, in his report, strongly recommended municipal ownership and urged as one reason why the present company demands so high rates that its plant is old in some of its parts and uneconomical. He suggested that the city should not on this account be required to pay high prices for its public lighting.

A NEWLY DISCOVERED DANGER FROM UNDERGROUND ELECTRIC CONDUITS.

Circular No. 20, of the Boston Manufacturers' Mutual Fire Insurance Co., for March, 1896, describes a remarkable case of a house, No. 10 Walnut St., Boston, being set on fire, on Nov. 28, 1895, in three places at the same time by electric currents, although there were no electric lighting or other strong electric currents used in the building. There was a three-wire Edison conduit in the street, and it appeared that the current escaped from the conduit into a near-by gas pipe, ran into the house by the gas service pipes and jumped from them to the water pipe, by which it returned to the street and was grounded. We quote the following from the circular:

On Nov. 28, a fire was found burning between the ceiling of the kitchen and the floor above. At about the same time, a second fire was discovered a few feet distant, and then a third appeared beneath a set bowl in the bath room. All of these fires were in the vicinity of gas or water pipes.

Investigation by the Boston Wire Department showed that heavy currents of electricity were passing through the gas and water pipes. The current was evidently entering the house through one system of pipes and leaving it through the other. Wherever the current passed from one system to the other the pipes were more or less melted, and in one case the gas pipes were found to be very hot, in fact, said to have been red-hot.

An attempt was made to short-circuit the current from the building by connecting the gas and water pipes, and a No. 9 copper wire was very quickly melted off. Such a wire would carry 200 or 300 amperes for a minute or two before melting—indicating, therefore, a very heavy current in the house.

The accident is explained as follows: An Edison underground conduit ran through Walnut St. This conduit is an iron pipe containing three copper conductors, one positive, one negative and one neutral, separated from each other and the pipe by an insulating compound. There is about 110 volts difference in potential between the neutral and the other two conductors. On digging up Walnut St., it was found that one of the conductors, at a point about 120 ft. from the house, had come in contact with the iron conduit pipe, due to a failure of the insulation. It was also found that the gas service pipe entering the house No. 10 was in contact with the outside of the Edison conduit pipe, and both pipes were found to be slightly fused at this point.

In Boston the neutral wire of the Edison Co. is grounded—this means that there was a complete circuit from the point where the insulation had failed, to the ground, by way of the conduit pipe, thence through the gas service pipe, thence along the gas piping in the house to the water pipe system, through various contacts; thence through the water pipe system out of doors to the underground network of water pipes, which would furnish a good ground. This means direct connection from one side of the system through the house to the neutral wire, it being at the same potential as the ground. The fires were started by the current forming arcs as it jumped from one system of pipes in the house to the other system.

On Nov. 29, the trouble occurred again; this time it was found that a second burn-out had occurred about 80 ft. from the first one.

Without venturing to suggest the best remedy for all such possible accidents, it may be interesting to note that in this case a connection by a large wire between the service pipes, located preferably just outside the wall would have obviated the trouble inside of the building. There were one or two other cases of similar troubles reported in Boston during the past year.

CHEMICAL PRECIPITATION OF THE SEWAGE OF LONDON IN 1895.

The average quantity of sewage treated at the two chemical precipitation plants connected with the sewage system of London was nearly 250,000,000 gallons a day in 1895. Some interesting facts regarding the operation of these works are presented in a report on this subject by Mr. A. R. Binnie, Chief Engineer to the London County Council.

The total quantity of sewage treated at Barking and Crossness during 1895 was 89,830,300,000 U. S. gallons, an increase of 1.08% over the year 1894. The chemicals used were 48,959,000 lbs., or 3.8 grains per U. S. gallon, of lime and 11,277,280 lbs., or 0.88 grains per U. S. gallon, of protosulphate of iron. The total amount of sludge produced was 2,169,000 long tons, or 4,858,560,000 lbs., which is about 5,400 lbs. per 1,000,000 U. S. gallons. The average amount of moisture in the sludge was 91.42%.

The total cost of the two chemical precipitation plants and the sludge ships used to convey the sludge to sea has been $4,728,770, of which $662,322 was for the ships. The fixed charges on this capital account in 1895 amounted to $248,000, and the operating expenses were $507,000, making a total of $755,000. This is equivalent to $8.40 per 1,000,000 U. S. gallons for all charges and $5.64 for operating expenses alone.

For precipitation only the operating expenses were $2.98, and for sludge disposal $1.66 per 1,000,000 U. S. gallons of sewage treated. These totals for operating expenses are slightly increased by some experiments with filtering the effluent from the precipitating tanks.

Six sludge ships were in use, carrying an average of 1,000 long tons each, the fleet making 2,169 trips about 50 miles in length. The cost of transporting the sludge to sea was 3.48 pence, or 6.75 cts., per long ton, which is 0.135 cts. per ton-mile for the distance hauled out, or half that sum if the return trip is included in the distance.

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The comparative tests of Portland cement made by American, English, German, Belgian and Danish manufacturers, which are published in another column, will, we believe, be examined with much interest by engineers. The experiments conclusively show that no nation has a monopoly of the manufacture of good Portland cement; on the contrary, the reputable brands of cement appear to be of about the same quality in one country as in another. This is after all what should be expected. Portland cement is made from certain well-known constituents, and if those are combined in proper proportions and the process of manufacture is correctly conducted, the product should be about the same, no matter where the manufacture is carried on.

There has been, and still is, a large amount of "superstition" concerning cement among engineers; and we even now hear it said that this or that or the other country is the only one that can produce "genuine" Portland cement. The diagrams on another page show admirably how slim foundation there is for such statements; and they especially show the fallacy of the still too common impression that American Portland cements are inferior to that of foreign countries.

The use of heavy rails, or even of good rails, in yards, is very generally assumed to be unnecessary and uneconomical in view of the severity of the service and wear, and this is one reason for the dilapidated yard tracks which are so common everywhere except at a few recent passenger terminal yards. The New York Central R. R. is now introducing its 100-lb. rails in the yards of the Grand Central terminal station, New York city and the results thus far obtained show a most decided economy in track work, in conjunction with other advantages. The yard has about 12 miles of track in all, laid with 65-lb. rails, but 250 tons of 100-lb. rails have been supplied, of which about 120 tons are already laid. The tracks laid with the heavy rails include those carrying the heaviest traffic between the station tracks and the four-track main line approach, and they are equipped with split switches, slip-switches, turnout frogs and crossing frogs, all of the 100-lb. rails. The yard is controlled entirely by interlocking plant, and the lever men in the main tower at first objected to the heavy switch rails, claiming that it would be very hard work to throw them. As a matter of fact these switches are found to work even more easily than those with 65-lb. switch rails, as the latter become bent vertically, causing them to bind and slide hard on the slide plates, whereas the former are stiff enough to hold their shape. The present yard force for track work averages 20 men, and the only Sunday work is for renewals and large repairs. Formerly the regular gang averaged 32 men, with about 16 extra men, and maintenance had to be carried on regularly on Sundays. Then constant work was required, and the tracks had to be surfaced about once a month, while the new tracks are left for months without any attention. When the rest of the principal tracks are laid with the heavy rails and the tracks have been surfaced, a still greater economy in maintenance work will be evident, owing to the reduction in repair work and renewals. Besides this, the switch engines running on the broad heads of the heavy rails will show less wear of the tires than when running on the narrower-headed 65-lb. rails, and this again will result in less wear and flow of the metal in the rails, and less injury to frogs and switches. With the more substantial track there is a noticeable decrease in derailments, which are usually more or less frequent in yards, while the tracks ride much more smoothly than the older tracks. The fact that good heavy new rails will reduce the wear of both tires and rails in yards as well as on the open road, and that the expenses of maintenance of track and equipment will be correspondingly reduced, have probably never occurred to many officials, and they have felt that it would be waste of money and material to put such rails in their yards. In regard to the Grand Central Station yard, it may be remarked that the frogs have no raising blocks in the heel, which is a specially important defect in a yard, where worn tires are more common than on the open track. The frogs have curved guard rails, the object of this being to free the wheel as soon as it has passed the frog point, and then allow the frog and wing rail to guide it, without putting any reliance on the guard rail.

The Sacramento-Folsom electric power transmission plant, which is described elsewhere in this issue, is the most notable achievement on record in the transmission of large amounts of power over long distances by electricity. The distance is 24 miles, and over twelve bare copper wires electric energy is transmitted to the amount of nearly 3,000 HP., with a loss in the line which is reported to be only 7½%. But the actual efficiency of transmission between the water wheels at Folsom and the motors in the Sacramento factories is of course vastly less than this. Suppose we start with the power delivered on the turbine shaft at Folsom, and assume efficiencies of the several stages of the transmission as follows: of the generators at Folsom, 95%; of the step-up transformers, 97%; of the line, 93%; of the step-down transformers at Sacramento, 97%; the percentage of the original shaft power which is delivered by the transformers at Sacramento will be the continued product of these efficiencies, or 83.13%. If this current is taken directly to the factories in Sacramento, and is there transformed into mechanical power, we may assume the efficiency of the line to the factory at 90% and of the small factory motors also at 90%, which, multiplied by 83.13, gives 67.33% as the perecentage of the original shaft power which will be delivered as shaft power to the factory. But a large portion of the current is converted from alternating into direct current in the substation before being distributed to users. Starting with the 83.13% of the original shaft power delivered by the step-down transformers, and assuming efficiencies as follows, viz.: for the synchronous motors, 95%; for the belt transmission to the direct-current generators, 95%; for these generators, 90%; for the line to the factory, 90%, and for the small motor at the factory, 90%, we obtain only 54.69% as the percentage of the original power delivered on the turbine shaft which is finally delivered on the shaft in the factory.

An interesting problem in governmental policy is now afforded by the proposed establishment of free navigation on the Monongahela River. On the banks of that river and its tributary, the Youghiogheny, are located the immense coal beds of the Pittsburg seam, which furnishes coal to all the towns on the Ohio and lower Mississippi River. All of this coal now has to pay tribute to the Monongahela Navigation Co., which furnishes slackwater navigation by means of a series of dams and pools. About five miles below Pittsburg is the Davis Island Dam, with movable wickets, which provides the cities of Pittsburg and Allegheny with a sufficient depth of water for navigation the year round, but below the dam the Ohio is too low for navigation during about six months in the year. The building by the government of a series of movable dams along the Ohio so as to insure navigation all the year round has long been desired, but on account of the expense involved there is no probability of its early accomplishment. The proposition immediately in view, however, is the acquirement by purchase of the rights of the Navigation Co., and making navigation of the river free. The result of abolishing the tolls now collected would be the cheapening of Pittsburg coal at New Orleans, which consumes 1,500,000 tons annually. In the meantime the coal operators in Birmingham, Ala., and vicinity, encouraged by the comparative high price of Pittsburg coal at New Orleans, and by liberal freight rates granted by the Southern Railway, from Birmingham to Greenville, on the Mississippi River, have opened a market for their coal at New Orleans, carrying it to that city from Greenville on barges. If the government should make the Monongahela navigation free, and improve the navigation of the Ohio, the Pittsburg operators may be able to put their coal in New Orleans at such a low price as to shut out the competition of the Alabama coal, thus benefiting the Pittsburg coal men and the New Orleans consumers and correspondingly damaging the Alabama coal men and the Southern Railway. On general principles, and in accordance with precedent, it would appear to be the correct policy of the government to make river navigation as free as possible, whatever present harm it may do to any particular section or railway.

STEEL RAILS FOR COMMON ROADS.

A good deal has been published in the newspaper press and elsewhere during the past few years concerning the scheme of laying steel rails upon ordinary highways as a means of making a better or cheaper road than is furnished by the ordinary macadam construction. Just where the scheme originated is doubtful. The idea has probably occurred to hundreds of men, merely as an idea; but the first to publicly advocate it, so far as we are aware, was the State Highway Commissioner of Ohio, Mr. Martin Dodge, in his report for 1893. A few months ago Mr. John O'Donnell, of Lowville, N. Y., a former member of the New York Railroad Commission, advocated a similar scheme in a paper read at a meeting of highway supervisors. Still more recently the idea has been taken up by Mr. Henry J. Budd, the New Jersey Commissioner of Public Roads, and general public attention was called to it by its advocacy in the annual message of Governor Werts, of New Jersey. Since that time newspaper clippings concerning the "steel rail highway" have been constantly flowing in upon us; and if people believe what the newspapers say, the public must certainly be getting educated to the idea that something of this sort is the coming thing in good road construction. It appears to be worth while, therefore, to give some examination to this proposed innovation, and see whether the balance of its probable merits and demerits is promising enough to warrant its actual trial in service.

For it must be said that all that has been done so far with the scheme is to put ideas on paper. No actual steel rail highway, solely for the use of ordinary vehicles, has ever been constructed so far as we know, nor have any actual working

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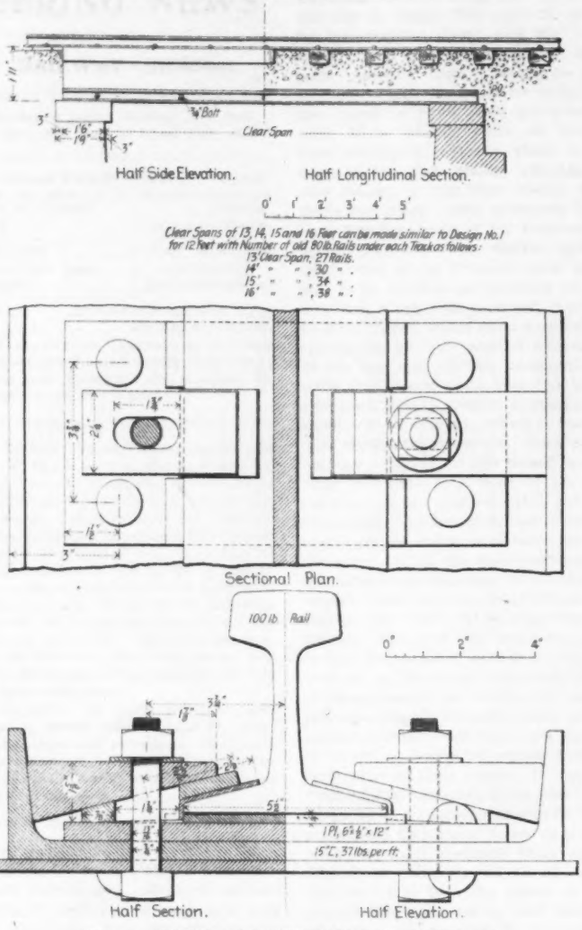
Half Side Elevation.
Half Longitudinal Section.
Clear Spans of 13, 14, 15 and 16 Feet can be made similar to Design No. 1 for 12 Feet with Number of old 80 lb. Rails under each Track as follows:
13' Clear Span, 27 Rails.
14' " " 30 " .
15' " " 34 " .
16' " " 38 " .
Sectional Plan.
100 lb. Rail
1 Pl, 6½" x 12"
15" C, 37 lbs. per ft.
Half Section.
Half Elevation.

FIG. 4. DETAILS OF WILSON'S RAIL FASTENING FOR BRIDGE FLOORS.

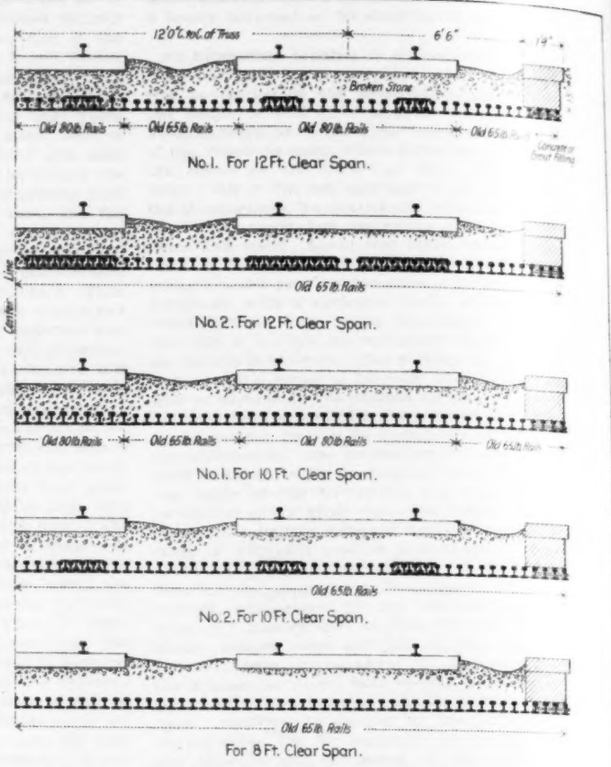
12'0" c. to C. of Truss
6'6"
Broken Stone
Old 80 lb. Rails
Old 65 lb. Rails
No. 1. For 12 Ft. Clear Span.
Center Line
No. 2. For 12 Ft. Clear Span.
No. 1. For 10 Ft. Clear Span.
No. 2. For 10 Ft. Clear Span.
For 8 Ft. Clear Span.

FIG. 1. RAIL-FLOOR BRIDGES; NEW YORK CENTRAL R. R.

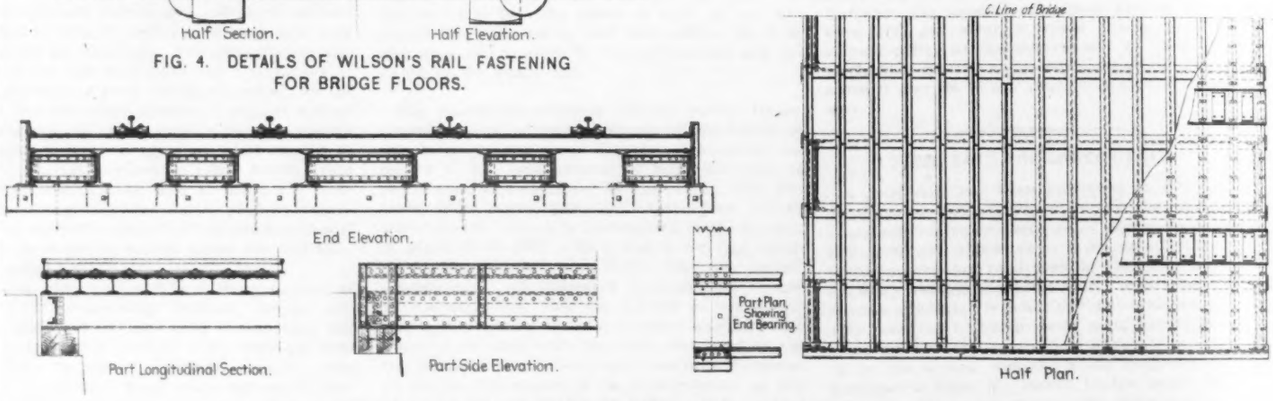

FIG. 3. TYPE OF SHORT SPAN BRIDGE, DESIGNED BY F. W. WILSON, JUN., AM. SOC. C. E.

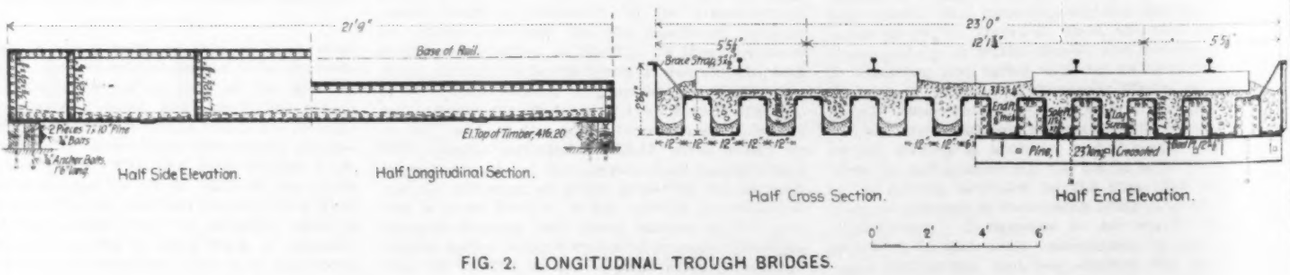

FIG. 2. LONGITUDINAL TROUGH BRIDGES.

SOLID FLOORS FOR BRIDGES OF SHORT SPAN.

CHAS. HART & SONS, LITH., 30 VESEY ST., N. Y.

drawings been prepared or accurate estimates made to test the merit of the system.

The Ohio Road Commission's plan was to lay rails for the joint use of ordinary vehicles and electric railways. It was even proposed, we believe, to let every man run his own private trolley car on these lines. Mr. O'Donnell proposed a rail 7 or 8 ins. wide of a channel section, laid on timber longitudinals, resting in turn on crossties, and the whole ballasted with macadam. Mr. Budd, the New Jersey Commissioner, gave the following details of his scheme:

> The claims as presented are that the average cost of a macadam roadbed 16 ft. wide is about $7,000 per mile. The cost of a double track steel railroad 16 ft. wide, filled in between with broken stone, macadam size, is about $6,000 per mile. The cost of a rural one-track road, $2,000 per mile. The rails to be made of steel the thickness of ordinary boiler plate, and to be formed in the shape of a grutter, 5 ins. wide with a square perpendicular shoulder ½ in. high, then an angle of 1 in. outward, slightly raised. This forms a conduit for the water, and makes it easy for the wheels to enter or leave the track. The advantages of steel rails are, first, longer wearing qualities than stone; second, one horse will draw on a steel track 20 times as much as on a dirt road, and 5 times as much as on macadam.

Now, with all due respect to the rail sections outlined above, we fear that their designers have forgotten the necessity of providing for joints, and also that after such a rail had been in use a short time, there would be such a "whack, whack" at every rail joint as would cause the road to be speedily condemned by its users. The designers of these sections appear to have had the idea that a broad tread was necessary to make a track suitable for ordinary vehicles. We know of no foundation for such an idea. In city streets it is exceedingly common to see vehicles following the narrow tread of street car rails; in fact, in some of the cobble paved streets of Philadelphia nearly all the vehicles keep to the street car rails and leave them only when absolutely necessary. Neither is much of a flange required on a rail to make an ordinary vehicle follow it. The tendency of wheels to follow even a very slight rut or groove is well known. It is fortunate that this is the case, for if it were necessary to have a deep groove or channel in a steel rail to keep vehicle wheels upon it, the success of the project would be very doubtful. Dust and mud would collect in any such channel and would greatly retard the movement of vehicles.

It appears to be evident that in the design of a steel-rail highway, we may as well cut loose from the ideas that have been put forth with respect to the details of such a construction and start afresh. The proper way to set about the design, moreover, is to see first what essential conditions must be fulfilled if such a system is to compete with ordinary macadam.

Evidently the first consideration is the cost of building and maintaining such a roadway, and the latter is quite as important as the former. No one questions that a macadam road is a very satisfactory type of construction. If the steel rail road is to compete with it, it must give as good all around service at less total cost, or if the cost is greater, there must be corresponding advantages. Moreover, if a steel track road is to be a success, it must be able to get along with no more repairs than are given to an ordinary hard road, and it must remain in fair condition if, by reason of a hitch in appropriations or other circumstance, it receives no repairs at all for two or three years at a time.

Again, it must carry without injury to itself the heaviest vehicles likely to use the road. There must be no difficulty in turning onto the rails or off them, for even on roads of such heavy traffic that a double track is laid, there will be constant occasion to turn off from and onto the rails to allow a vehicle to pass another going in the same direction.

It must further be remembered that both the winter frosts and the heavy rains of the mud season must be withstood; and while a dirt path between the rails might do in dry summer weather, the above considerations make evidently necessary some permanent footway for the horses.

Bearing the above principles in mind, we have designed a cross-section for a steel rail highway, and present it herewith for discussion. Fig. 1 shows the proposed form of rail. It will be seen to be similar to a standard I-beam, except that the upper flange is of slightly crescent shape to aid wagon wheels to follow it, and a little extra metal is placed there to allow for wear and corrosion. Such a section would weigh about 8 lbs. per ft., and could be rolled in any rolling mill equipped to turn out small beams.

Fig. 2 shows a proposed standard cross-section for a single-track roadway 12 ft. in width. It will be seen that the rails are laid directly on the broken stone, and a telford foundation, 18 ins. in width, is laid beneath each line of rails. The broken stone is filled in to a depth of 8 ins. at the center of the roadway, and lessens to 4 ins. at each side. It is filled in solid to a level with the top of the rail head on each side. The rails are kept to gage by cross-pieces made of 2×¼-in. steel with the ends bent at a right angle and bolted to the web of the rail. A spacing of 4 ft. would probably give a sufficient number of these gage rods. For the rest, the construction would be exactly like that of a first-class macadam roadway. It will be evident that liberal use of the roller upon the foundations would be essential to a good piece of work.

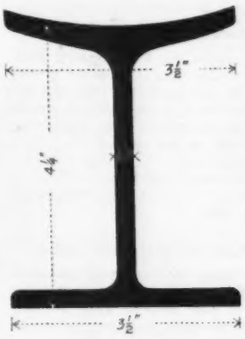

Fig. 1.—Proposed Section of Rail for Highways.

Fig. 3 is a design for a double track highway, which will be seen to require a 16-ft. roadway. The construction is similar to that of the single-track.

It will be noticed that in these designs the use of wood is entirely dispensed with, either for cross-ties or longitudinals, and we believe this to be essential if any such construction is designed to compete with a first-class macadam road. If the rail is supported on a wooden foundation,

Fig. 3.—Half Cross Section of Proposed Steel Rail Highway, with Double Track and 16-ft. Roadway.

decay and settlement are bound to occur sooner or later, and the cost of tearing up the surface of the macadam to repair such settlement and keep the track in surface would be fatal to the success of the scheme. The idea in the designs shown in the accompanying cuts is to make the rail support so permanent that settlement will be impossible, and it will never be necessary to tear up the roadway. The repairs which would be needed to such a roadway would be resurfacing to keep up the horse path at the center as it wears hollow, and to keep the roadway beside the rail exactly level with it.

Taking up now the question of the cost of such a roadway as that shown in Fig. 2, it is evident in the first place that its cost will not be greatly different from a macadam roadway of the same width, plus the cost of the rails, rail joints and gage rods. These we may estimate as follows for a mile of road:

5,280 lin. ft. of single track at 16 lbs. per ft. = 63,480 lbs. = 31.7 tons, at say $25 per ton, =	$792.50
1,320 gage bars at 9 lbs., at 1.2 cts. per lb.	142.56
352 rail joints at 25 cts.	88.00
	$1,023.06

The cost of laying the rails, including the cost of preparing their foundation, we may offset against the saving due to the use of a thinner layer of macadam than is generally considered sufficient, though it is probable that this is being a little too generous to the steel-rail construction. In fact, the weakest point in the designs shown in Figs. 2 and 3 is probably the thinness of the macadam coat on the sides, and it would very probably have to be made somewhat thicker in any place where the subsoil was bad or the drainage poor, to prevent wheels cutting through it in wet weather.

In round numbers, then, we may compute that a single-track steel rail roadway would cost $1,000 per mile more than a macadam road of the same width. Now, the advocates of steel-rail highways have confidently asserted that such a construction would be vastly cheaper than a stone road. Is there any way in which the accompanying designs could be modified to make them in fact cheaper?

Of course, it is always difficult to say that anything is or is not impossible, but we confess we fail to see how a permanent steel rail roadway could be built except on lines close to those of our design. Suppose the weight of the rails were lessened one-half; it would effect a reduction of only some $400 in the cost per mile. The macadam at the sides might be omitted; but on roads of much traffic the result would be apt to be deep mud on each side of the rails in the fall and spring. Of course, in regions where good, gravelly soil is available, this might be used instead of macadam for the entire road, save for a top dressing of stone screenings next the rails; but in such regions the basis of comparison is generally a road built of the country earth, and not a macadam road, so the result of the comparison is after all about the same.

If a temporary construction were desired, wooden supports for the rails might suffice, and a dirt filling between the ties; but while such work might be suitable for roadways built by private concerns in some special cases, it should be entirely clear that no such thing would be at all satisfactory for a public highway.

If, now, the position be correct that a steel-rail highway must cost practically $1,000 per mile more than a macadam road, the question for consideration is simply, Would the road with the rails laid in it be enough better to warrant its extra cost? Let us see in what points such a roadway might be expected to prove superior to the ordinary macadam road.

(1) The wear of such a road would be less, resulting in a smaller cost for maintenance. The wear of an ordinary macadam road is due much more to the action of wheels than horses' hoofs. Theory indicates this when the load per square inch due to a horse's shoe is compared with the concentrated load due to a rolling wheel which theoretically rests on a mathematical line on its circumference. The hoofs roughen the surface, but the wheels grind it to powder. It is quite common to see ruts of considerable depth worn along the wheel tracks on macadam roads, while the center of the road is hardly depressed at all. On a steel-rail road the wear due to the wheels would be nearly eliminated, with a corresponding reduction in the cost of annual repairs.

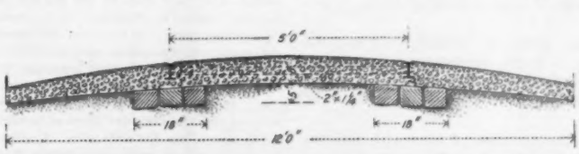

FIG. 2.—CROSS SECTION OF PROPOSED STEEL RAIL HIGHWAY, WITH SINGLE TRACK AND 12-FT. ROADWAY.

(2) The traction would be less. The resistance to traction on a level macadam roadway is variously stated at from 40 to 120 lbs. per ton. Probably 75 lbs. is not far from right for the average of roadway new and worn, wet or dusty. On a steel rail the traction is generally taken at the very low figures of 5 to 12 lbs. per ton, which have been obtained by experiments on steam railways. But on any rail laid in a street, even in a paved street, much higher figures for traction resistance should be taken. On such a track as that shown

in Figs. 2 or 3, it would not be safe to count upon a resistance to traction of less than 25 to 30 lbs. per ton. Instead of a horse drawing five times as much on a steel-rail highway as on macadam, as claimed by Mr. Budd, the animal would actually draw, it is probable, not more than twice or possibly three times as much ON A LEVEL as on a macadam road. But on a 4% grade the resistance due to the grade would amount to 80 lbs. per ton, and the total resistance per ton would be for steel rails, say, 120 lbs.; for macadam, say, 155 lbs. It should not, therefore, be hastily assumed that loads can be doubled on a steel-rail highway, except where there are no grades of considerable steepness or length to be surmounted.

But it is to be remembered, that even where a road of level or very light grades is under consideration, it depends upon the traffic it is to carry whether decrease in traction resistance due to the use of steel rails would result in any real gain in practical importance. On a pleasure driveway in a city park, for example, it is plain that no gain would result, and to a large extent the same thing would be true on a city boulevard, or in the residence streets of popular city suburbs, where almost the only wagon that ever passes loaded with as much as the horses can draw is the coal dealer's delivery wagon. On the other hand, in a busy manufacturing district, along a level load where heavily loaded teams are continually passing, the reduced cost of carriage due to the use of steel rails might repay the additional cost of such a road every month.

Besides the two main advantages of the steel-rail highway which we have just discussed, it is probable that there would be some gain in freedom from dust and in lessened noise. It is the rolling wheels on the ordinary macadam road that grind its surface to fine powder, which the wind distributes as dust. As for the noise, one can easily settle that question by comparing the noise made by a wagon driving along a macadam roadway and that made by the same wagon when running along the rail of a street railway track laid in the same roadway. It will be noticed that both these considerations are of importance where city streets are concerned, but of practically no moment as respects ordinary country roads.

If the preceding discussion is well founded, the conclusions that must be reached with respect to the future of the street-rail highway are obvious. The idea that this method of construction furnishes a cheap substitute for a standard macadam road appears to be wholly erroneous. On the other hand, there appears to be a reasonable prospect that a steel-rail highway could be adopted to advantage in the following situations:

1. For roads where plenty of gravelly soil is at hand, but which have so much travel that the gravel wears out rapidly, necessitating frequent repairs. On such roads steel rails might save their extra cost by reason of the reduced wear on the roadway.

2. For roads or streets where macadam is now in use, but on which travel is so heavy as to rapidly wear the surface. Here again the use of rails might be profitable to save wear and postpone the heavy cost of a pavement of brick or asphalt.

3. For roads over which a considerable amount of heavy hauling is done, especially where such roads have very light grades.

4. For suburban roads or streets, to save dust and noise.

We believe that the promise of favorable results in some of these situations is sufficiently good to warrant the construction of an experimental section of such a roadway as we have described in some location where there would be best promise of resulting benefit. By using ordinary standard 4-in. beams instead of the section which we have shown in Fig. 1, the cost of a single mile of such a road should not exceed by more than $1,500 to $2,000 the cost of an ordinary macadam roadway. It is possible that by laying such beams with the tops of their flanges depressed slightly below the surface of the roadway, as good or better results would be secured than with the form of rail head which we have shown in Fig. 1.

We shall hope to see such an experimental section of roadway laid down and tried in actual service at no distant date. The promise of an enormous market for steel for the construction of such roads, in case of a successful outcome of the experiments, makes it well worth while for any of the great steel manufactories to undertake the construction of such a roadway, or perhaps some of our progressive State Highway Commissions may be induced to try the experiment.

LETTERS TO THE EDITOR.

Eight-Wheel Passenger Locomotive; N. Y., O. & W. Ry.

Sir: The description of engine No. 1 of the New York, Ontario & Western Ry., in your issue of April 30, is very good and correct except in one particular. The fire-box is not of the Wootten type, but is a wide fire-box similar to the Wootten. The latter includes a large combustion chamber which does not exist in this engine.

Yours truly,
Cooke Locomotive & Machine Co.,
Fred. W. Cooke, Vice-President.

Paterson, N. J., May 2, 1896.

Formulas for the Elements of Unequal Leg Angles.

Sir: I have received so many requests from interested parties for blue prints relative to the subject of Unequal Angles, noted on p. 274 of your issue of April 23, that I feel that I must arrange for some other way for distribution.

Thomas Marshall's Foundry & Structural Works, which I represent as Chief Engineer, expects in the near future to publish a little work illustrating the important points in the design of the modern "sky-scraper" and I will have the formulas above referred to incorporated in this work.

Yours very truly,
Carl Schinke.

Chief Engineer Thomas Marshall's Foundry & Structural Works.

28th and Railroad Sts., Pittsburg, Pa., April 29, 1896.

Civil Service Examination for Engineers.

Sir: The New York City Civil Service Board will hold examinations on the followniq dates:

May 11, for Building Inspectors and Inspectors of Iron and Steel. The law requires that "the inspectors shall be competent men, either architects, civil-engineers, masons, carpenters or iron-workers, who shall have served at least ten years as such." May 14, computers; May 18, mechanical engineers.

The examinations will consist of writing, arithmetic, technical knowledge and experience. Citizens of the United States, 18 years of age and over, are eligible to examination.

Applications may be obtained by addressing the undersigned.

S. William Briscoe.

New Criminal Court Building, New York City, April 30, 1896.

Singular or Plural?

Sir: I was rather surprised to learn through your correspondent, quoted in your issue of April 23, that "people of literary distinction" would say, "a 50 feet span;" but not so much surprised at his further statement: "Our modern engineers, even of the highest standing prefer foot to feet in this connection." So much the better for "our modern engineers," for they are correct in using the singular form, the "people of literary distinction" notwithstanding, or the earnestness of the Boston instructors who so doggedly insisted on teaching the writer that "ten-foot pole" is an error. I hold in my hand a copy of Kerl's grammar, which was then used in the Boston (Mass.) schools, from which I quote as follows: "It is, however, proper to say 'a ten-foot pole'—'a five-cent savings bank,' etc.; 'a ten-feet pole'—'a five-cents savings bank' are improper."

It is true, however, that grammar is but a child of custom and subject to change at the hands of various authorities; yet in this instance, as you well state, the best writers use the singular form of modifier, and there seems to be no reason for difference of opinion, for certainly "a 50-foot span" is more euphonious than "a 50-feet span."

Yours respectfully,
Geo. T. Prince, M. Am. Soc. C. E.

1707 Farnam St., Omaha, Neb., April 27, 1896.

La Rue's Formula for the Curvature of Chords.

Sir: In his reply to my letter printed in your issue of April 30, Mr. La Rue mistakes the point at issue. My statement has reference only to the error in his facts and not to any numerical amounts. The section α—β I have shown could just as well have been made through post P_2. In all the panels with inclined chords, no counters are intended to be placed, the curvature of the top chord can easily be arranged so as to avoid any necessity for counters. Moreover, Mr. La Rue's way of getting at the amount of counterstrains is charmingly easy and off-hand; he must know that to get at the counter strains with theoretical accuracy can be done, but would involve the employment of a dozen expert mathematicians for a few days. In practice we have to content ourselves with rough assumptions, and it is therefore best to avoid the pesky things as much as possible, especially since with curved chords it can be done so easily and will at the same time lead to economy in design. Mr. La Rue's admission that his main statement is wrong, knocks the props from under his whole article and makes his line of curvature purely arbitrary and without practical value.

Yours truly,
Henry Szlapka.

761 E. State St., Trenton, N. J., May 2, 1896.

Methods of Working the Mississippi River Dredges.

Sir: In your very interesting article describing the new hydraulic dredge to be used on the Mississippi River (Eng. News, April 23) there are a few conclusions arrived at which it seems might bear some slight comment.

In the first place, the tow-boat scheme of operating the dredge, proposed by Mr. Bates and approved in your editorial columns, has been tried in connection with the "Alpha," another dredge owned by the Mississippi River commission, and found to be impracticable.

It is only with the greatest difficulty that the most powerful tow-boat owned by the commission can make headway against the swift river current in towing the "Beta" up stream when the cutters are just submerged. If, then, we add to this the task of forcing the cutters into a sand or gravel bank with a vertical face of from 7 to 10 ft., and of holding and handling the dredge in a cut very little wider than her hull (the "Beta" draws 6½ ft. instead of the 4½ ft. specified in the contract), we will far exceed the capacity of any two tow-boats on the river of sufficiently light draft to work in from 4 to 6 ft. of water, about the average depths on the crossings in low water.

The wonderful results to be obtained by shortening the discharge pipe to 200 ft. will also, I think, contract appreciably when this is tried in actual service.

The direction of the current is not, as Mr. Bates has it, along the crest of the sand bar and at right angles to the line of cut, but across the bar and nearly coincident with the line of dredging.

This means that there is no so called "leeward side of the cut" where the current would "spread the sand over a very considerable area, out of the way of the channel;" but that the end of the discharge pipe is practically the point where the sand would be deposited, with reference to distance from the cut.

Baffle plates on the end of a 200-ft. pipe might possibly give a deflection of 75 ft. against the swift current at a crossing. This would not be sufficient even to carry the sand beyond the limits of the proposed channel.

Yours truly, F. H. Hilliard, C. E.

99 Madison St., Memphis, Tenn., April 30, 1896.

Comparative Tests of American and Foreign Cements.

Sir: In commenting editorially upon the Melan Arch bridge, to be built at Topeka, Kansas, you state that the specification for Portland cement is "the strictest that you remember for a long time on any important engineering work." It may be of interest to know that the requirements in the specification for cement to be used, in the construction of the Pennsylvania Ave. subway and tunnel (Eng. News, April 16, 1896), several important bridges, numerous main and branch sewers, in the repairs to the Queens Lane reservoir, and many other municipal works in this city, involving the expenditure of millions of dollars are higher than those in the specification to which you refer. As proof of this, a copy of the specification regulating the quality of the cement delivered for use during 1896 is enclosed. In reference to the possibility of American Portland cements meeting the requirements, diagrams are also enclosed showing the average results of tests (classified as American, Belgian,* Danish, English and German) made in this laboratory during 1895, from samples of cement actually used in municipal work. These diagrams which have been compiled from the results of the breaking of over 9,000 briquettes made from 38 different brands of cement, show clearly the superiority of the American cements.

Very truly yours,
Richd. L. Humphrey, Inspector of Cements.

Philadelphia, Pa., April 8, 1896.

(The following is an abstract of the specifications mentioned by our correspondent.—Ed.)

The acceptance of a cement to be used shall rest with the Chief Engineer, and will be based on the following requirements: Natural cement shall have a specific gravity of not less than 2.5 and shall leave, by weight, a residue of not more than 3% on a No. 50 sieve, 15% on a No. 100 sieve, and 35% on a No. 200 sieve. The sieves being of wire cloth of No. 35, 40 and No. 40 wire (Stubb's gage), having 2,500, 10,000 and 40,000 meshes per sq. in., respectively. Pats of neat cement one-half (½) inch thick, with thin edges immersed in water after hard set, shall show no signs of checking or disintegration. It shall develop initial set in not less than ten minutes, or

*The tests of the Belgian cement were not obtained from the natural Portland cements but from artificial Portlands and are the average results of tests of cements which met the city requirements.

hard set in less than 30 minutes. This being determined from pats of neat cement ½ in. thick, temperature between 60° and 70° F., the amount of water used being just sufficient to make a stiff plastic paste. Briquettes 1 sq. in. in cross section shall develop the following ultimate tensile strengths:

Age.	Strength. lbs. per sq. in.
24 hours in water after hard set	100
7 days, 1 in air, 6 in water	200
28 days, 1 in air, 27 in water	300
7 days, 1 in air, 6 in water, 1 cement to 2 standard quartz sand	120
28 days, 1 in air, 27 in water, 1 cement to 2 standard quartz sand	200

Portland cement shall have a specific gravity of not less than 3, and shall leave, by weight, a residue of not more than 1% on a No. 50 sieve, 10% on a No. 100 sieve, and 30% on a No. 200 sieve; the sieves being the same as previously described. Pats of neat cement ½ in. thick with thin edges, immersed in water after hard set shall show no signs of checking or disintegration. It shall require at least 30 minutes to develop initial set, under the same conditions as specified for natural cement. Briquettes of cement 1 sq. in. in cross section, shall develop the following ultimate tensile strengths:

Age.	Strength. lbs. per sq. in.
24 hours, in water after hard set	175
7 days, 1 in air, 6 in water	450
28 days, 1 in air, 27 in water	550
7 days, 1 in air, 6 in water, 1 cement to 3 standard quartz sand	160
28 days, 1 in air, 27 in water, 1 cement to 3 standard quartz sand	220

All cements shall meet such additional requirements as to hot water, set, and chemical tests, as the Chief Engineer may determine. The requirements for set may be modified where the conditions are such as to make it advisable.

All mortar is to be composed of 2 parts clean, sharp, dry-screened tide-washed bar sand and 1 part of cement. Mortar for pointing shall be mixed in proportion of 1 part Portland cement to 1½ parts of sand. Mortar for grouting shall be mixed in the proportion of 1 part of cement to 1 part of sand. A greater portion of cement shall be used when required. The ingredients, properly proportioned by measurement, must be thoroughly mixed dry in a tight box of suitable dimensions, and the proper amount of clean water added afterwards. No greater quantity is to be prepared than is required for immediate use, and any that has set shall not be retempered or used in any way. Mortar taken from the mixing box, and molded into briquettes 1 sq. in. in cross section, shall develop the following ultimate tensile strengths:

Age.	Strength. lbs. per sq. in.
7 days, 1 in air, 6 in water, 1 natural cement to 2 sand	50
28 days, 1 in air, 27 in water, 1 natural cement to 2 sand	125
7 days, 1 in air, 6 in water, 1 Portland cement to 2 sand	125
28 days, 1 in air, 27 in water, 1 Portland cement to 2 sand	200

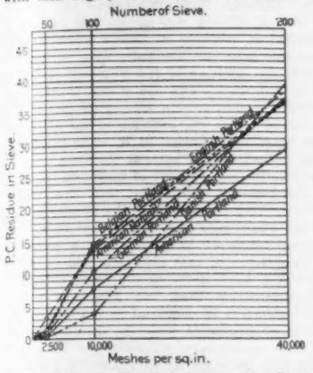

Fig. 1.—Diagram Showing Comparative Fineness of American and European Cements, Averaged from 9,000 Tests of 38 Brands of Cements.

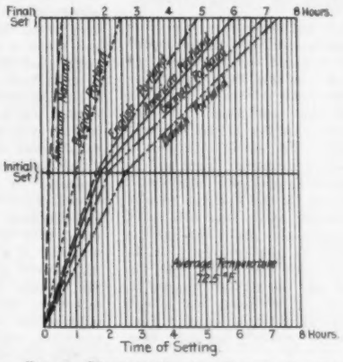

Fig. 2.—Diagram Showing Comparative Rapidity of Setting of American and European Cements, Averaged from 9,000 Tests of 38 Brands of Cements.

(In explanation of our editorial statement regarding the severity of the cement specifications for the Melan arch at Topeka, Kan., reference was had particularly to the heat test for constancy of volume. This was as follows:

Cement made into thin cakes on glass plates shall not crack, scale or warp under the following treatment: Three pats shall be made and allowed to harden in moist air at from 60° to 70° F.; one of these shall be subjected to water vapor at 176° F. for three hours, after which it shall be immersed in hot water for 48 hours; another shall be placed in water at from 60° to 70° F., and the third shall be kept in moist air.

The specifications sent by our correspondent and printed above, call definitely only for the normal cold water test, for constancy of volume, the proviso for "hot water" and other tests evidently being intended simply as a precautionary measure open to the chief engineer in case of doubt. While some dispute exists regarding the practical utility of hot water tests, it is quite generally conceded that they are more severe than cold water tests and in definitely requiring a hot water test in all cases the specifications for the Topeka, Kan., bridge are unique enough to be noticeable although they are by no means the first or the only specifications requiring such a test. In respect to requirements for tensile strength, the specifications of our correspondent are unusually severe. Interest will, we think, be attracted chiefly by the diagrams showing the results of comparative tests of American and European cements, as this is a question to which American engineers have been giving considerable attention lately. —Ed.)

Analyses of Portland Cements.

By whom made.	Kind.	Silica.	Alumina.	Iron.	Lime.	Magnesia.	Sulphuric Acid.
Foreign.							
Candlot, Paris	German	22.20	8.32	2.88	61.40	0.90	1.73
	French	23.00	8.33	3.87	60.90	1.10	1.40
	English	23.50	8.43	3.47	59.64	0.97	1.78
	Belgian	24.50	8.51	2.84	60.03	0.88	1.54
Henry Reid, London	English	25.00	12.0		60.00	1.00	1.00
De Smedt, Washington	Brook Shoobridge	22.74	11.44		57.68	0.51	0.60
	Alsen German	24.90	11.22		59.98	0.38	0.86
Richardson, Washington	Knight, Bevan, English	19.75	7.48	5.01	61.38	1.28	0.97
"Giant" American.							
Faija, London	Giant	23.45	13.23		61.37	0.66	1.37
De Smedt	"	23.36	8.07	4.83	59.28	1.00	.50
Detweiler	"	22.90	12.10		60.13	1.00	0.87

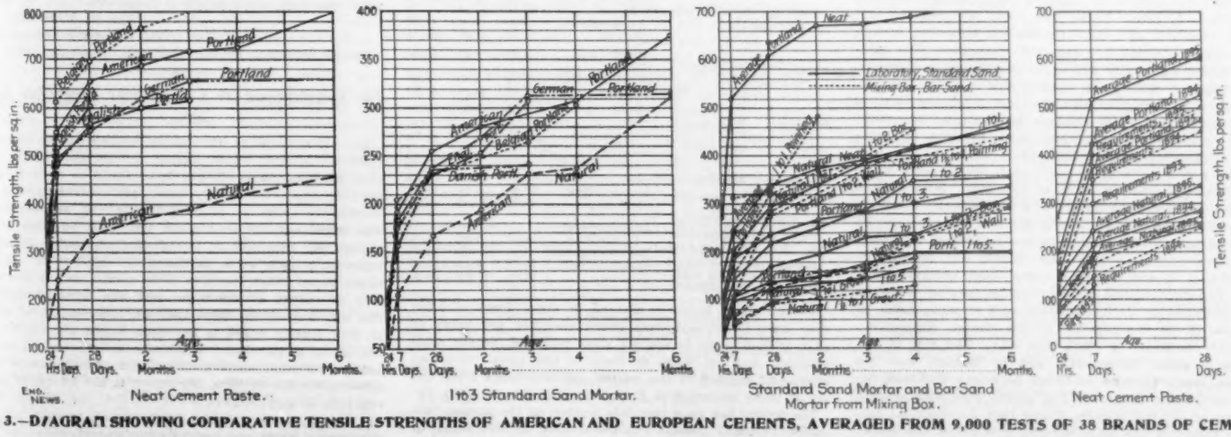
Tensile Strength, lbs per sq in.
Age.
Neat Cement Paste.
1 to 3 Standard Sand Mortar.
Standard Sand Mortar and Bar Sand Mortar from Mixing Box.
Neat Cement Paste.

FIG. 3.—DIAGRAM SHOWING COMPARATIVE TENSILE STRENGTHS OF AMERICAN AND EUROPEAN CEMENTS, AVERAGED FROM 9,000 TESTS OF 38 BRANDS OF CEMENTS

American and European Portland Cements.

Sir: In the recently published specifications for the concrete of the Melan arch bridge at Topeka, Kan., published in your issue of April 23, there appears the following gratuitous attack on American Portland cement: "It is not probable that any American natural Portlands (so called) will meet these requirements."

So far as the importance of the Topeka bridge is concerned, the lowest bid for which was $125,000, it is certainly no more important than the Johnstown bridge, of the Pennsylvania R. R., which stood the great floods of 1889 and 1894. Nor is it any more important than the New London, Conn., bridge of the New York, New Haven & Hartford R. R.; the new East River bridge of the Long Island R. R.; the new Delaware River bridge of the Pennsylvania R. R.; the Schuylkill River bridge of the Baltimore & Ohio R. R.; the Athens, Pa., bridge of the Lehigh Valley R. R.; the Falls bridge of the Philadelphia & Reading R. R.; the new cantilever bridge across the gorge at Niagara Falls, or the hundreds of other bridges on the railways in question, which have been built in whole or in part with "Giant" American Portland cement.

It involves certainly no more responsibility than such enormous dams as those of the New York aqueduct system, at Purdy's, Carmel, Crafts, Sodom, Quaker Bridge and Bog Brook, or those of the Scranton Water Co., at Dunning's, Oak Run and Dunmore. It presents certainly no greater risk than the construction of the gigantic tunnel and power house at Niagara Falls. In traffic of passengers, in stress of moving loads, it can never compare with the great Broad St. station at Philadelphia, the Baltimore station and Jersey City terminal station of the vast Pennsylvania R. R. system, nor even in these elements can it compare with the Philadelphia & Reading R. R. terminal station at 12th and Market Sts., Philadelphia. Certainly the travel, the jarring, the strains on the concrete masonry of the cable roads in Philadelphia, in Pittsburg, and the Ninth Ave., Lenox Ave., Lexington Ave. and 23d St. cable roads in New York will equal the anticipated travel and strain on a $125,000 bridge at Topeka, Kan. And yet all these important works were done almost exclusively with "Giant" American Portland "so called," "which it is not probable will meet the requirements" of a bridge in the great metropolis of Kansas.

As to tests, it is a well-known fact that American Portland cements do meet all the specifications of the most exacting engineers and the fact that last year nearly 25% of the total consumption of Portland cement in the United States was of American manufacture, as against only 13% five years ago, is the best proof of the matter in a business way, though it would be easy for American manufacturers to fill up much valuable space in your paper with dry tables of figures and diagrams to further prove that which the best engineers in the country already recognize as an established fact.

Some tests published in the "Brickbuilder" for May, 1895, and copied in several of the engineering journals, in reply to a criticism on American Portland cement, gave records of nearly 300,000 bbls. Giant American Portland cement on seven of the most important pieces of work in the United States up to periods of five years, and were accompanied with the suggestion that some similar tables of foreign Portland cements showing equal results

be furnished. Though months have passed no tests have yet appeared. Comment is unnecessary. So much for this branch of the question.

Now, as to the words, "American natural Portlands (so called)." True, Portland cement is an artificial product. It is made by combining argillaceous and calcareous materials in certain proportions and driving the resultant product to incipient vitrifaction by the heat of a kiln, and subsequently grinding the clinker to powder. In England, clays are added to chalk, lias rocks to limestones; in Germany and Belgium, clays are added to maris or chalks, and limestones to clays; in France clays are added to chalks and also to limestones. In all these cases, the first step is to secure the raw materials, which, when combined, will, after calcination, give the proper analysis of a Portland cement. These secured and their proportions established, the next step is to make a new stone, or form, out of these ingredients, so as to present a new artificial material of uniform character to the elements of combustion. In all these cases, the broad process has been to mix the two ingredients carrying respectively, first, lime, and second, the silica and alumina in a raw condition with water; the material having prior to that state of the process been reduced to the condition of a fine pulp or powder, according to whether the grinding was in a wet or dry way. The material thus produced, whether by wet grinding in the shape of a cream or paste, or by dry grinding in the shape of a mud, is either allowed to dry, or is dried artificially and is made into bricks, blocks, balls or other forms. This new artificial stone or rock thus formed is composed of finely comminuted particles of lime, silica and alumina, all in close mechanical union. This being the process up to the kiln, it would seem, therefore, that there could be no difference between a brick composed of any of the various mixtures above referred to, provided that the silica, alumina and lime were present in proper quantities and in proper forms. Certainly the Topeka specifications make no distinction between foreign cements made of varying natural constituents. Now, American Portland cement is made at Warner's, Jordan and Wayland, New York, out of mari and clay, precisely similar to materials used in Europe. The process up to the moment of shipment is precisely the same as that practiced in the best mills I have visited this winter in Europe, and why American Portlands of this kind are given the name of "American natural Portland, so called," I leave it to the author of the Topeka specification to answer, for they are just as much true Portlands as any in the world.

As to the second and larger class of American Portland cements, which are made by combining limestones with argillaceous limestone rocks, as is the practice in the Lehigh District of Pennsylvania, the cement is certainly a true artificial Portland cement. If a true Portland cement can be made in Europe by combining two such varying materials in texture and weight as limestone and clay, or chalk and clay, it certainly can be made in America by combining two limestones of similar textures and weights, but of varying constituency in argillaceous matter. This is what is done in the Lehigh District. A laminated argillaceous limestone of sedimentary rather than igneous formation, may be taken to represent almost the sedimentary deposit or slurry formed by the settling of the chalk and clay in the "settling backs" of European works. To this limestone, which contains lime as well as the clayey (argillaceous) matter required, is added sufficient of another limestone, higher in calcareous matter to bring up the proper chemical proportions of lime. These two rocks are crushed and ground together, and their mechanical structure broken down and distributed into atoms or molecules. The powder is mixed with water and made into the form of bricks. The bricks are made up of small grains of powder, which, rearranged mechanically with the lime, silica and alumina that were formerly in separate laminae, or not thoroughly mechanically combined, now brought in thorough mechanical combination, and ready in this new form of a new artificially made rock, to be acted upon in a chemical crucible, such as the kiln. Now such a material, made first by nature in a mechanically arranged natural rock, possessing nearly all the qualities of the slurry or composition formed by the settling of the chalk and clay mixtures in European works, and second, by man adding to and breaking down these natural rocks, and by fine grinding and careful mixing, maxing an even more mechanically perfect artificial rock or stone, must be the equal if not the superior of the foreign composition or slurry composed of chalk and clay. The rest of the process is alike, in America and in Europe, and the analyses here presented of Giant American Portland cement, by leading authorities, in comparison with similar analyses of foreign brands, shows that no chemical difference exists in the manufactured product of the European or American works.

Tried, therefore, in the crucible of practical use in the largest public works in the country; tested by all the leading engineers of the United States, under the most exacting specifications, American Portland cement has within the past 15 years won its way to the front rank. Similar in its chemical ingredients, identical in the methods of its manufacture, alike in the artificial character of its preparation with the foreign cements, it is just as much entitled to be "called" not "so called" an artificial Portland cement, as they are, unless in some mysterious way the free air and free labor of America may be claimed to exercise some evil influence upon the chemical ingredients and convert them into some "so called" combination which the author of the Topeka specifications does not name, and which so far is not described in any of the leading works of chemistry.

We did not bid upon this specification for the good reason that we are not in the habit of "going to parties" when the host in his invitation intimates that we are not "expected."

Yours truly,

American Cement Co.,
Robert W. Lesley, Vice-President.
22 South 15th St., Philadelphia, Pa., May 2, 1896.

Comparative Merits of American and Foreign Cements.

Sir: Referring to your article and editorial in your issue of April 2, on the specifications for the Melan bridge to be built at Topeka, Kan., I would say that the Commercial Wood & Cement Co. bid on this work, guaranteeing the Saylor's American Portland cement to meet the specifications. Whether by the expression "so-called Portland" some slur is meant to be cast on the Portland cements manufactured at Coplay, Pa., out of a mixture of argillaceous limestone and pure limestone, such as the Saylor's and other brands made at that point, the writer does not know, but as about 70% of the Portland cement made in America is manufactured at or near this point from such materials; and very nearly all of the balance of the Portland cement made in this country is made from mari and clay, it seems more than likely that the author of these specifications had the former cements in view, when using this phrase. If this party had looked up the subject of manufacturing Portland cement from argillaceous limestone, he would probably not have used such a term.

For the information of those not knowing what constitutes a Portland cement, I would say that the Association of German Cement Manufacturers bind themselves to the following declaration:

The undersigned members of the Association of German Portland Cement Manufacturers bind themselves to produce under the name of Portland cement only such articles as are made by calcining a thorough mixture, consisting of calcareous and clayey substances and then grinding same to the fineness of flour. Any article made in a manner differing from the above method or to which during, or after burning, any substances have been added, is not considered by them as Portland cement and the sale of such product under the designation of Portland cement is regarded by them as deceiving the purchaser. This declaration does not apply to such minor additions, which are made to regulate the setting time of Portland cement and which are permitted to the extent of 2%.

Therefore, the term Portland cement means in a German factory a mixture of clayey substances—which contain silica and alumina—with calcareous substances, which contain lime. The proportions of this mixture is about 3 of lime to 1 of silica, this composition to be calcined and ground, and it is exactly what the term Portland cement means in an American factory.

In the winter of 1892-93, the writer visited the leading Portland cement factories in Europe and got samples of their raw materials, clinker and composition. The analysis of a few of them follow:

		Silica.	Alumina and Iron.	Lime
"Dyckerhoff" Factory, Germany	Chalk or marl	1.40	1.04	54.08
	Clay	60.44	25.24	1.70
	Composition	15.32	8.00	41.00
	Clinker	21.10	11.28	64.73
"Hanover" Factory, Germany	Chalk	2.98	6.28	50.44
	Clay	...	....	....
	Composition	13.94	7.88	39.80
	Clinker	21.17	14.31	61.51
"Germania" Factory, Germany	Chalk	3.36	2.68	52.34
	Clay	....	....	....
	Composition	13.42	5.96	41.98
	Clinker	....	....	....
"Aalborg" Factory, Denmark	Chalk	3.24	1.25	53.72
	Clay	47.24	16.36	15.43
	Composition	15.88	5.12	42.41
	Clinker	23.20	10.55	63.92
"Saylor's" Factory, Coplay District, U. S. (70% of the Portland Cement made in America is made from the materials in this District.)	Argillaceous Limestone	16.77	6.50	41.37
	Limestone	3.64	.61	52.93
	Composition	15.18	6.42	42.97
	Clinker	23.00	11.00	63.90

At the above factories located in these districts, after they have pulverized their materials, they are taken in such quantities as to make a good Portland cement composition, and on what grounds is the term "so-called Portland" applied to the cement manufactured from one set of these materials if it is not applicable to all?

The writer has gone into this matter, as the phrase "so-called Portland cement" is often used by the seller of foreign cement, who frequently knows nothing about the manufacture of his own cement, or any other cement for that matter, and it is only to belittle the American product, which is fast displacing the foreign cement on large engineering work in this country. The writer thinks, in the interest of fair play, that the use of this term, as applied to American Portland cement, should be stopped.

As to the severity of the specifications, I would say that the strength required for the neat and sand mortar is not unusual for first-class engineering work in Philadelphia; in fact, they are not as high as many specifications for private or city work. The specifications for the city work covers every barrel of Portland cement used, whether it is for a small brick sewer or a large concrete bridge; and in private and public work, where such specifications are in force, the American Portland cements are used almost exclusively. The fineness of 95% through a 10,000 mesh sieve is also not higher than has been required for the last three years on much of the work done in this city, notably the additions to the University of Pensylvania, improvement of the Harrison properties at 10th and Market Sts.; 10th and Filbert Sts., and 15th and Market Sts., in which work American Portland cement has been largely used.

As to the hot-water test, that is nothing new to find in specifications, although little importance can be attached to the results. It is a well-known fact that by a very small addition of sulphate of lime a manufacturer can make a cement pass the hot-water test, which cement, previous to the addition of the sulphate, probably cracked badly in hot water, and the writer thinks that most engineers and manufacturers will agree that if the cement was unsound before the addition of the sulphate, it was unsound after the addition of it, even though it then passes the hot-water test without cracking.

The clause calling for not over 2% of magnesia has also appeared in specifications frequently, but the writer would like to know from the author of the Topeka bridge specifications on what data he bases his idea that more than 2% of magnesia is harmful in a Portland cement? If a restriction of this kind was generally insisted upon it would work more to the disadvantage of the foreign manufacturers than the American manufacturers. The restriction of magnesia in a Portland cement seems to have originated with the German manufacturers, who after considerable discussion on the effects of this material had the quantity allowable in Portland cement placed at 3½% by the Association of German Cement Manufacturers, and then in order to ascertain if more than such an amount was detrimental a committee was appointed to investigate the subject and make experiments covering a period of five years. The committee reported in 1895. A majority report signed by Dr. Schott, Herr Meyer and Dr. Arendt was as follows:

Our investigation in part, extending over a period of five years, failed to show an injurious effect of magnesia in Portland cement, in the composition of which magnesia replaces an equivalent of lime. The presence of magnesia up to 8 or 10% causes no harmful expansion or cracking of the cement, even after several years.

The minority report by Herr R. Dyckerhoff was summarized as follows:

The presence of magnesia up to 3% in a Portland cement produces no change in its properties. From 4% on, however, magnesia, if sintered, whether added or substituted for a part of the lime, has an injurious effect producing increased expansion and decreased strength after long periods. This injurious effect is the stronger, the higher the percentage of magnesia. If the cement is not sintered, however, a higher proportion of magnesia, even to 18%, may be harmless.

Mr. Dyckerhoff, however, recommended that the allowable limit of magnesia in Portland cement be placed at 5% instead of 3½%. The results of these experiments, although not identical, prove at any rate that if an engineer places the limit of magnesia at 4%, which is 100% more than the Topeka bridge specifications call for, he is well within the bounds of safety, and at the same time would have larger competition for his work than if the limit was kept down to 2% of magnesia.

Wm. G. Hartranft,
V.-P. Commercial Wood & Cement Co.
Girard Building, Philadelphia, Pa., April 24, 1896.

The Specifications for a New Water Supply for Jersey City.

Sir: It appears to me that in criticising the specifications for a new water supply for Jersey City in your your issue of April 30, you have failed to keep in mind that the city can only buy water, and cannot build waterworks. In order to proceed legally and successfully it was important not to confuse this with building waterworks. My own opinion is that the proceeding should be regarded simply as a purchase of supplies in order to safely come under the law. This means only a specification of quality of the water and the point of delivery. The city authorities were anxious, however, to go as far as they legally could to get such works as would make the option to purchase, which the law authorizes, a valuable privilege; consequently, the specifications were drawn with this in view. My report to the Board, of which you have a copy, says:

In preparing the specifications the fact that you are purchasing water and not building water-works has been kept in mind. The procurement of an option to purchase the works is clearly only an additional measure of precaution and safeguard over what is already furnished by the laws. As I have said, it does not bind the city to take these works if they are not built in a substantial and acceptable manner, nor does it prevent the city from taking them at a fair valuation, which may be determined at any time in the future by due process of law.

Please for a moment take the position of the contractor. He is simply called upon to furnish water to be paid for by the million gallons. The city does not and cannot

obligate itself to purchase. His financial support must be obtained, therefore, with a view to continued ownership of the works, and under those circumstances any one who has had any experience with financiers knows that they would prefer to and would probably insist upon, designing and building their own works as nearly as possible in their own way. Hundreds of cities have obtained a supply by granting a franchise to water companies, and in nearly every case you are aware that the water company has prepared its own plans. This proceeding is analogous to that and has no similarity whatever to cases where the municipality builds with its own money. If you criticise this method of procedure, it is entirely unfair that you criticise the specifications. If there is any fault it rests with the legislature, as no other course is possible for us, as I have clearly stated in my report. Would you consider that I had any right whatever to proceed on lines which were legally impossible? Whether this is the most advantageous method of procedure or not is not a question for me to consider. I was not instructed to report on the propriety of existing legislation.

I have stated that a year would be required to make necessary surveys and prepare such plans as would be suitable to receive bids on. Being an engineer you know how specific such plans must be. No such specific plans are asked for from the bidder, since he is only to furnish pure water and provide safe delivery therefor. A number of companies have been competing during the last four years for this contract, and all of them have their plans already prepared. Newark obtained a supply by contract in two years and six months, although on the signing of the contract there were no specific plans prepared, and even the source of supply was not specifically designated in the contract. I mention this because it is the only precedent which we have to follow, and because I believe that under its contract Newark will obtain entirely satisfactory water-works before their final acceptance by the city.

As to the filtration specifications, you will find that I made no recommendation that bids be asked for. What I do say in my report is as follows:

> These considerations are presented to make it clear to you that, while purification to a certain degree is possible there are doubts about the wisdom of committing your city to such a course, and if filtration is considered at this time at all, it should be under such circumstances as will relieve the city of the risk of financial loss through failure. These, also, are the reasons why I must report in favor of exhausting all reasonable means of procuring a pure gravity supply from a distance on the lines indicated by specifications A and B.

You also say that I "seem to be rather sceptical regarding the merits of filtration anyway." You will find from my report that the only scepticism which is expressed therein is what is expressed by the Massachusetts Board of Health and their Consulting Engineer, Mr. Davis, in reporting on the Metropolitan Water Supply. I cannot understand why I have been charged with being an enemy of filtration, and why you should join in this charge. I believe that filtration has its use, and there are cases where I have recommended it, but my position in regard to the Jersey City supply is that that is not one of these cases, and the reason therefor I have expressed in my report. The Passaic has, above Belleville, a drainage area of some 900 square miles, and of this about one-half is on the gneissic highlands, the supply therefrom being of excellent quality. The other half, being the lower part of the watershed, is on the red sandstone, and has enormous areas of flat and wet lands embracing a total of some 30,000 acres. It is an agricultural country, and is becoming densely populated. Within 50 years it would be about one-half a city. The only reason that the Passaic water has ever been tolerable is because of its pure highland branches. When these are diverted we will have left a stream which, like all the red sandstone streams, is inferior in quality from natural causes. In addition to this it must always be seriously polluted, even should the collected sewage be discharged by intercepting sewers. There is no way in which Jersey City can protect itself from this diversion of the pure head-waters. It will always be an extremely difficult thing to prove that there is any scarcity of water at Belleville from the fact that the stream there is tidal; moreover, the diversion of the water, while it will seriously affect the quality of the water at Belleville, cannot be blamed for what will be directly chargeable to pollution by surrounding cities. No matter what may be said by those who advocate filtration under all circumstances, good and bad, I maintain that no city should ever draw its supply from a source in the midst of another large city, or group of cities.

You will find, however, that I do point out that filtration may be useful to Jersey City under certain conditions, but my point is that attempts to procure a pure gravity supply should not yet be abandoned, and that for the present filtration legally must and should be placed on the same plane with gravity bids. In a recent issue your journal pointed out the probable superiority of a pure gravity supply over a filter supply.

I quote as follows from my report:

> We willingly admit that, in view of the obstacles which surround and impede your efforts to procure that supply of pure water which your city so much needs, filtration may possibly yet prove to offer at least a temporary solution of the problem which you might wish to avail yourselves of.

And again I say "that filtration is possible, and that the Passaic water could be greatly improved thereby does not admit of question." These quotations should be sufficient to show you that I had no intention "to put a permanent quietus on all plans for filtration, while pretending to yield to the public demand for a filter supply." I am decidedly of the opinion that there is no public demand for a filtered supply, and I do not know where you obtained the idea that there is. There has been a clamor for something of the kind, but you should satisfy yourself that, outside of a handful of honest advocates, that clamor does not mean either obstruction pure and simple, or an agitation in the interest of some corporation. There is nothing more absurd than the view which many take on this question, that there is a unanimous desire to proceed on the part of the water monopolies. Some of them do not desire any steps to be taken for procuring a new supply for very good reasons, and to be misled into the belief that all obstructive attempts are in the interests of the people of Jersey City, and all constructive efforts are in the behalf of the water monopolies betrays lack of familiarity with the real situation.

You say further that "any one familiar with filtration knows that filtered water has never been supplied on this basis, and therefore no one stands ready with the necessary experience to enter into such a contract." You refer to supplying filtered water by the million gallons, which is the only course open to us under the law, as I have repeatedly said. Your statement would have applied exactly to the furnishing of water to Newark from any source or under any conditions in 1889, when the contract was made by that city, and to-day that is the only important instance where water has been procured in this manner, and yet it was procured in that way at that time. I cannot understand why you should apply such a criticism in any case, as it is a criticism only of the state legislature, and should not be applied to the specifications.

Mechanical filtration, you should know, was intentionally excluded. (We so stated last week, saying of the manufacturers of mechanical filters, "they are carefully excluded by the terms of the specifications."—Ed.) It may have its uses, and I have no doubt that it has, but common sense dictates that it should not be applied to the purification of this badly polluted water.

Your criticism as to the chemical standard in the filtration specification is certainly not justified. It ought to be evident that under the conditions of the specification, the purification of the water being the contractor's purpose, he should be called on to maintain the water at some safe standard measured by the ordinary tests of chemists and bacteriologists. The fact that he cannot predict what the condition of the water will be 25 years hence is merely a criticism of the whole attempt to purify this water, and agrees with my position throughout. The paragraph headed "Pollution Must be Prevented" in the other specifications could not apply to this because that does not contemplate any process of purification, and the condition of the gathering grounds is a matter for examination at any time, so that sources of pollution can be readily detected and the contractor required to remove them. In this case it is known that the supply is, and will probably continue to be badly polluted, so that such an inspection would be of no earthly use. You might criticise the requirement that the number of bacteria shall be stated. My own opinion is that this test is considerably over-rated in importance, as it is rather the kind than the number which we have to dread, and in the present state of science it is extremely doubtful if identification of the harmful kinds can be made with certainty. So your criticism might go on ad infinitum. If you go back to the starting point, however, and read my report to the Board carefully, and take account of all the conditions as they actually exist, with many of the details of a technical and legal nature which have developed during the course of this attempt to procure water, I think you will find that the specifications represent a careful and honest effort to solve a very difficult problem. It is apparent from your criticism that you are fully aware that we are proceeding without precedent, but in some way you seem disposed to blame the city authorities and myself for this state of affairs. I do not expect you to suggest a definite and feasible method of procedure which would fit the circumstances, as you are not employed for that purpose, but I think if you attempted to do so I would find it easier to criticise you than I have found it to prepare these specifications. The position of Jersey City is entirely novel and unusual, and neither the city authorities nor myself can be held responsible for this. I am satisfied that you have not fully taken account of this fact in preparing your criticism.

Yours truly, C. C. Vermeule.

71 Broadway, New York, May 4, 1896.

(Mr. Vermeule has had unusual opportunities to become familiar with many features of the water situation in Jersey City. He is author of the valuable report on water supply, issued last year by the New Jersey Geological Survey. He was engineer for one of the informal bidders for a water supply for Jersey City a year ago. Last fall he was employed by the city to assist it in upholding the award of a contract for a new supply to the Jersey City Water Co. The declaration by the Court that this award was invalid resulted in the new call for bids, and Mr. Vermeule is now employed as engineer for the proposed new supply.

Mr. Vermeule is therefore qualified to discuss the limitations under which the city must secure a new supply, and we gladly give space to his ideas on the subject. This we do the more readily because the communication indicates that in his opinion our criticisms of some features of his specifications should be addressed, if at all, against the legal conditions to which he attributes them, rather than against the specifications themselves.

We see no reason for modifying our criticisms of the gravity specifications, further than to say that we did not intend to blame Mr. Vermeule for circumstances over which he had no control, and we may add that perhaps the seeming helplessness of Jersey City in this matter should be laid on her local authorities rather than the State Legislature.

The granting of franchises for complete water-works systems, cited by Mr. Vermeule as analogous to the proposed Jersey City contract, is mostly confined to small cities and towns, and some of the results obtained under this plan, as well as the experiences thus far had and yet to be expected under the Newark contract, which is similar to that under discussion, might well serve as warnings of how not to, instead of how to, do it.

Mr. Vermeule urges in justification of the short time allowed for preparing bids that several contractors have had plans for a gravity supply ready for some time past. This may be one reason for the vagueness of the gravity specifications, but we do not see how it makes it any more possible for other contractors to bid intelligently under either the gravity or filtration specifications.

Regarding the specifications for filtration, we are still of the opinion that no bona fide bids can be expected under them. If the local conditions are such as to render any other plan for a filtered supply impracticable, if filtered Passaic River water is undesirable, and if, as Mr. Vermeule urges, there is no real public demand for filtration, why ask for bids for such a plant? But if filtration bids are to be invited, and if they must be solicited on the million-gallon basis, we see no reason for asking contractors to enter into absurd and impossible guarantees regarding the amounts of chlorine and nitrates in the filtered supply. We pointed out last week that these conditions rendered the specification for filtration farcical, but Mr. Vermeule does not allude to this matter further than to say that our "criticism as to the chemical standard in the filtration specification is certainly not justified," and then go on to urge the necessity of standards of purity. We did not object to proper standards of purity, but to the impropriety of some of those actually laid down.

Not only are some of these standards inexplicable, but the shortness of the time allowed for preparing filtration bids is equally so. It needs no detailed argument to show that 19 days is altogether too short a time to select a site and make plans and estimates for a 35,000,000-gallon filter plant, with a low and high lift pumping station and extensive pipe lines; to determine the character of the water in question with sufficient certainty to design the plant and to guarantee the results for 25 years; to estimate the price at which water can be furnished or the plant sold outright; and last, but not least, to make the necessary financial arrangements.

Regarding mechanical filtration Mr. Vermeule makes the following sweeping assertion:

> It may have its uses, and I have no doubt that it has, but common sense dictates that it should not be applied to the purification of this badly polluted water.

No grounds are given for this opinion, nor anything to indicate why a guarantee of the results from mechanical filtration backed by a bond for $500,000, as required by the specifications would not be as good during the next 25 years as a like guarantee for sand filtration.—Ed.)

Notes and Queries.

By a printer's error, the name of the *Terry & Tench* Construction Co., the contractors for the erection of

the new Harlem River drawbridge, for the New York Central & Hudson River R. R., was misspelled in our description of that structure in our last issue, it being printed as the Terry & Trench Construction Co.

THE ST. PAUL BUILDING, NEW YORK CITY.

In the construction of very lofty buildings New York city is now rivaling Chicago, as is evident by many of the structures now completed or in course of erection in this city, and this style of construction is still on the increase in spite of the very reasonable objections by architects and others for aesthetic and sanitary reasons. The property

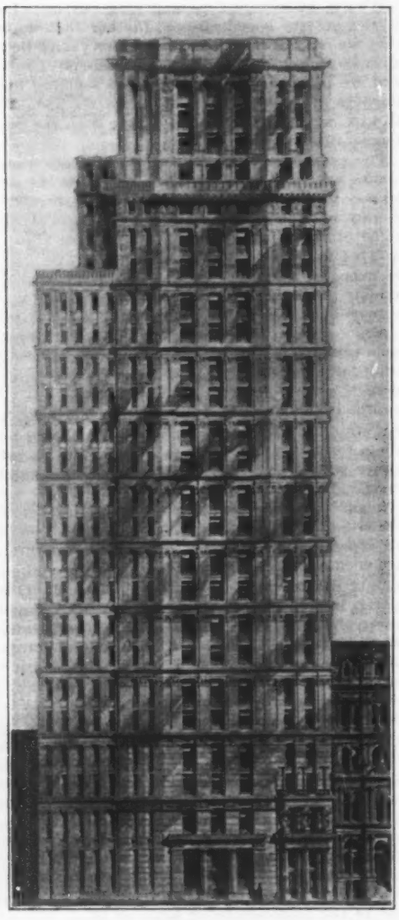

Fig. 1.—St. Paul Building, New York City.
George B. Post, Architect.

owners, however, demand the greatest possible rentable space on their ground area, and this demand will continue to be met until some legislative action is taken to restrict the height of buildings.

We illustrate this week the St. Paul Building, which is now being erected on the site of the old Herald Building, and which will fortunately front upon the wide, open space in front of the Post Office, at the junction of Park Row and Broadway. The architectural design of the building will thus be seen to advantage, while Broadway will not be seriously affected by the height, although Ann St. (which is very narrow) will be entirely overshadowed. The design of the building, as shown by the elevation in Fig. 1, is severely simple and yet strong, and it is notably free from petty details and ornaments which, in such a building, are not seen to advantage and only serve to mar the general appearance. Such details are unfortunately too often employed by architects, who evidently do not grasp the principles of treatment required for a lofty and narrow front. The building will be about 313 ft. high from the curb line, and will have a basement, sub-cellar, 25 stories, and an attic lighted by skylights. It will be faced entirely with yellow Indiana limestone, which will give a light and cheerful appearance to the structure. Work was commenced in the summer of 1895, and it is expected that the building will be ready for occupancy during the autumn of 1896. The building was designed entirely by Mr. Geo. B. Post, of New York, the eminent architect (who has designed a number of the other large buildings in the business section of New York), and we are indebted to him for plans and information used in the preparation of this article.

One of the most important considerations for a structure of this kind is the character of the foundation to be adopted, not only on account of the weight (and many tall office buildings of the modern style of construction have weights considerably less than those of older but smaller buildings), but on account of the serious effects of any unequal settlement which might cause the upper part of the building to overlap the property line, while a third important question is that of cost. Since an office building is intended to be a remunerative investment it is essential that the architect should consider his design from a commercial as well as a constructional point of view, and select a foundation system which will involve the minimum expenditure of time and money in securing a reasonable degree of safety and permanence. Borings made on the site of the St. Paul Building showed that the rock lay at a depth of about 86 ft. 6 ins. below the curb line, and was almost level. The overlying material is a clean, compact sand, almost free from clay, and very firm, the character being uniform for the whole depth. A test well was sunk and pumped out daily for five or six weeks, in order to establish the level of the ground water, and this was found to be 32 ft. below the curb, corresponding very closely with the level of high tide

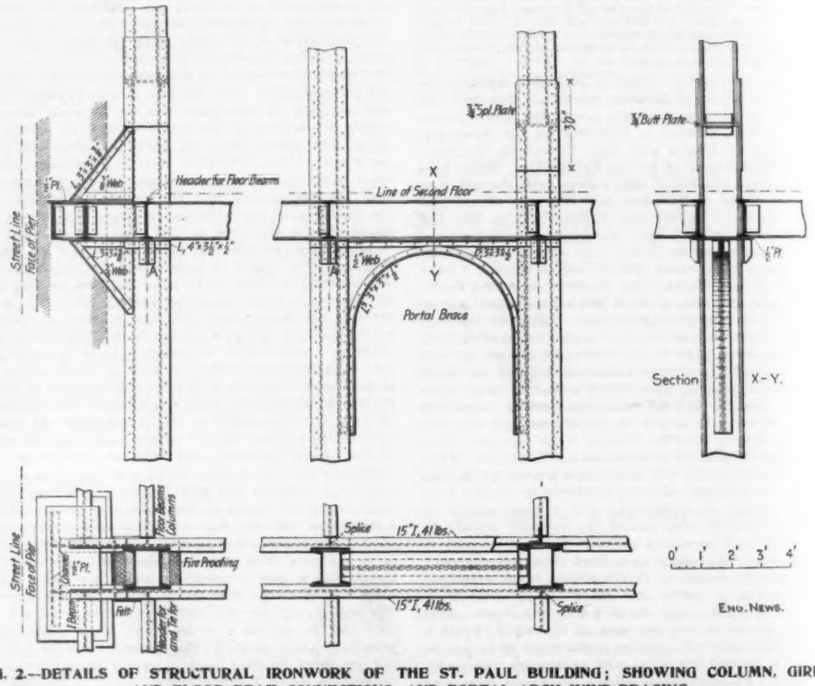

FIG. 2.—DETAILS OF STRUCTURAL IRONWORK OF THE ST. PAUL BUILDING; SHOWING COLUMN, GIRDER AND FLOOR BEAM CONNECTIONS, AND PORTAL ARCH WIND-BRACING.

in the East River and the Hudson River. Similar conditions exist in several parts of New York city, and many of the large and heavy buildings in the vicinity of the St. Paul Building are founded on this sand formation, and the foundations have proved thoroughly substantial and permanent. These buildings include the World, Mail & Express, Temple Court, Vanderbilt, Tribune, Times and Potter buildings, and the ponderous structure of the New York Post Office. Some of these impose bottom loads of 4½ to 5½ tons per sq. ft. (while the World Building has an eccentric loading which gives over 4 tons per sq. ft. under the east front wall). They show no settlement, and the successful and satisfactory results in these actual cases are more valuable in proof of the reliability of the foundations than any experiments could be.

It may be noted here that the American Tract Society Building, described and illustrated in our issue of Dec. 27, 1894, is built upon a similar sand foundation, but has piles, about 15 ft. long, driven over the entire area of the foundations, and capped by concrete. In view of the disturbance of the sand by driving the piles, and the reliance upon the skin friction of the piles as a sustaining power, it is considered by some engineers that in case of the construction of foundations by pneumatic or hydraulic caissons in an adjacent lot, there would be more liability of a movement of the sand (by disturbance due to air or water escaping from the caisson work and percolating through the sand) than if the building rested on a flat foundation.

Various foundation systems were considered for the St. Paul Building, and estimates of their cost were prepared, and it was found that the caisson system would involve a very heavy expense, and would materially increase the time required for the completion of the building, and these questions had to be taken into account in their commercial relation to the total cost of the new building and the loss of rent during the period of its erection. The sand at the site of the building was found to be remarkably clean and compact, and through which water would percolate but slowly, the sand being so compact as to cause the twisting and destruction of the auger boring plant (which was preferred by Mr. Post to water jet boring, as being more reliable than the latter). It was also found that by occupying a sufficient area of the surface of the sand, the bottom loads from the foundation could be reduced to a trifle over 3 tons per sq. ft., which it will be seen is considerably less than that of other buildings in the same neighborhood, already noted. It was, therefore, decided to place a flat foundation on the sand at the level of the ground water; this latter provision preventing any injurious current of water through the sand (from springs, sewers or a broken water main, etc.), which might wash away the sand from under a foundation above the level of the ground water. The washing away of sand from below the present foundation could only be effected by pumping from wells or tubes on adjoining property, and this would not be permitted by law. The excavation was, therefore, carried down about 31 ft. 6 ins. below the curb, reaching a very compact sand, and this was at once covered with 12 ins. of concrete, so

as to prevent any disturbance of the solid sand below. Upon this was built the concrete and iron grillage foundation.

In order to assure himself of the security of this foundation, Mr. Post requested two eminent engineers (Mr. Charles Macdonald, M. Am. Soc. C. E., and Mr. Theodore Cooper, M. Am. Soc. C. E.), to test and report to him the bearing capacity of the soil. To do this a hole about 14 ins. sq. at the bottom (that is, at the surface of the sand) was cut through the concrete at the south end of the lot. A sample of the sand was taken and found to contain about 3% of clay. The sand was, of course, saturated with water, being below the level of the ground water. A yellow pine timber 12×12 ins., full section, 14 ft. long, and planed to exactly 12×12 ins. (or 1 sq. ft.) at the end, was then placed vertically upon the sand bottom, being guided vertically and fitted with a loading platform. The weight of the timber and the platform was estimated at 1,500 lbs., and with this initial pressure upon the soil a gage mark was made and referred to a mark on a bracket attached to the neighboring building, to which all depressions were afterward referred. The loading of the platform was then commenced, no care being taken to put the weights on slowly or gently, nor to avoid oscillation, but on the contrary, the load was frequently shaken. The loads were also left in place for days at a time. The results of the tests were as follows:

Time, 1896.	Load, lbs.	Depression, ins.
March 26, 1:10 p. m.	1,500	....
1:25 "	4,000	⅛
1:40 "	6,000	3-16
March 27, 1:45 "	6,000	3-16
2:10 "	10,000	5-16
March 28, 12 noon	10,000	⅜
March 31, 1:15 p. m.	10,000	⅜
1:35 "	13,000	15-32
April 2, 2:00 "	13,000	9-16
April 6, 5:00 "	13,000	19-32
April 8, 1:00 "	13,000	19-32
April 13, 4:00 "	13,000	19-32
April 14, 2:30 "	13,000	19-32
April 15, 2:30 "	13,000	19-32
April 16, 2:30 "	13,000	19-32

On April 8, as the load remained stationary even under oscillations, eight buckets of water were poured into the hole, filling it to a depth of about 15 ins., and the load was then set in oscillatory motion. As this load of 6½ net tons was sustained without change under these conditions, it was decided to see what effect in producing settlement would be caused by an adjacent cut through the concrete floor, giving vent to the underlying material. A hole, similar in size to the first one, and about 4½ ft. from it, c. to c., was then cut through the concrete, and completed by 4 p. m., April 13. There being no evidence of motion under this new condition by 2:30 p. m., April 14, eleven buckets of water were poured into the test hole, filling it to a depth of about 21 ins. In a few minutes the increased moisture of the sand at the second hole gave evidence of the passage of water through the sand. While the test hole was filled with water, the loaded platform was strongly and repeatedly pushed on one corner in order to set up oscillation, and the load was left until the next day. At 2:30 p. m., on April 15, there being no evidences of the least change, both holes were filled with water and left until 2:30 p. m., April 16. As it was then found that there was no movement of the loaded stick and no raising of the sand in the second hole, the test was discontinued.

The engineers, therefore, reported that they considered the foundation entirely safe, and that a similar building could be built on the adjacent property without difficulty if the work is carried on properly and with reasonable caution.

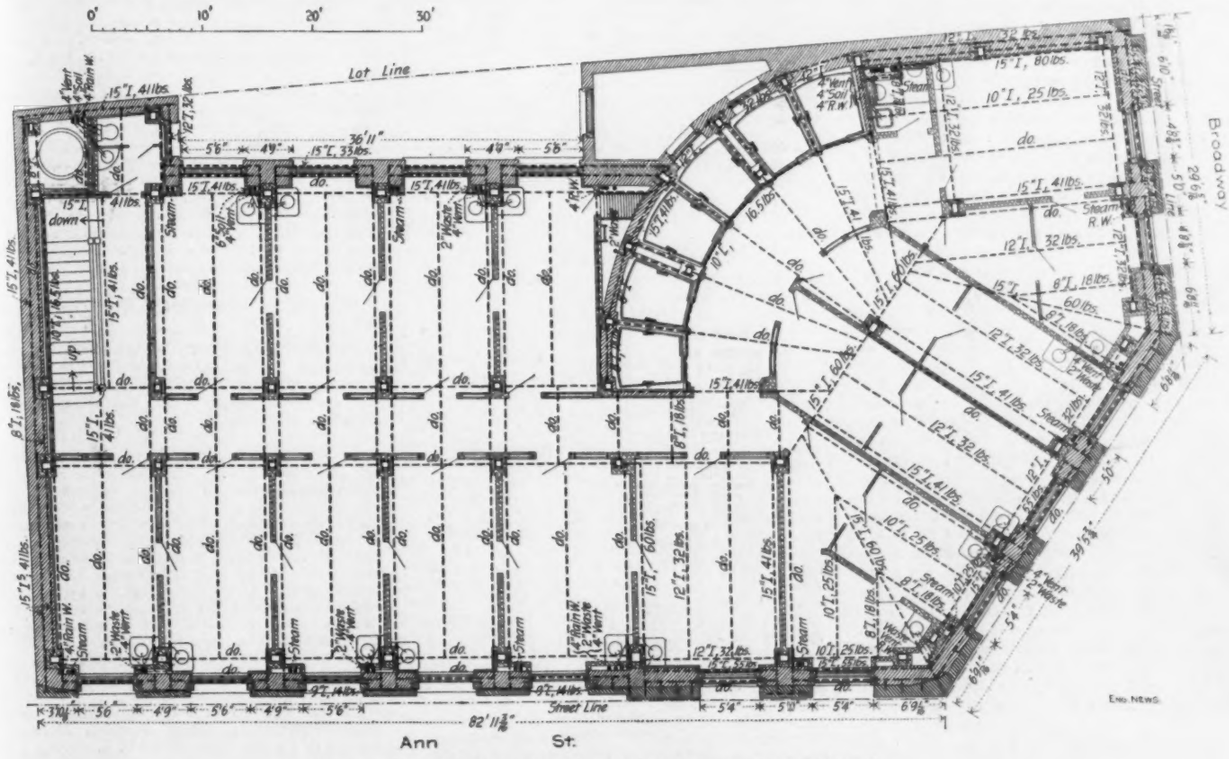

FIG. 3.—FLOOR PLAN OF FOURTH STORY OF THE ST. PAUL BUILDING.

Upon the 12-in. concrete floor is the actual foundation floor, consisting of I-beams of proper dimensions, arranged in horizontal groups with reference to the column loads. These are firmly united by separators and tie-rods, and are laid as close together as possible, allowing room for ramming cement concrete between them to form a solid mass. This grillage extends over nearly the entire area of the lot, and upon it are lines of cross girders, the dimensions of which are proportioned to transmit the loads of the column bases to the grillage. The bending moments of both grillage and girders were carefully computed, and all eccentric loading of the foundation is avoided.

It was at first proposed to construct a joint foundation on the line of the party wall, to carry the adjacent wall of any new building subsequently erected on the site of the present Park National Bank Building. With such an arrangement, this part of the foundation would carry only 1.6 tons per sq. ft. (until such time as the other building might be erected), while the other part would carry 3.2 tons per sq. ft. (on the bottom of the foundation), which latter loading was estimated by Mr. Post, from past experience, to produce a settlement of ⅝ in., or perhaps somewhat more. In consequence of the great height and small base area of the building, its steel structural frame must necessarily be made extremely rigid in order to provide for wind strains and other lateral stresses. Any uneven settlement of such a rigid framework would cause it to be severely strained, and means had, therefore, to be considered for taking up any unequal settlement and preserving the integrity of the bracing. It was, therefore, determined to make the steel column bases of such shape that hydraulic jacks could be inserted under the columns, so that columns upon the party wall foundation could be jacked up, have the packing plates removed from between each column and its base, and then be lowered so as to correspond with the settlement of the columns carrying heavier loads. Should the subsequent loading of this foundation cause these columns to settle more than the others, they would be jacked up again and the packing plates be reinserted. This arrangement would also permit the straightening of the building in the unlikely event of any unequal settlement causing it to lean slightly over the adjoining lot (and a very slight inclination would be serious in a height of 313 ft.), so as to interfere with the erection of another tall building in that lot.

As a matter of fact, it was eventually decided to build entirely independent foundations, and the provision for adjusting the settlement of the columns was rendered unnecessary. The column bases, however, had already been designed and ordered, and as there was no reason why they should not be used, even though the use of jacks would probably never be necessary, they were used in the work.

The structural framework consists of columns of box section, with arch portal bracing in certain panels, and with floor systems of I-beams. The main columns, one of which is shown in Fig. 1, are built up of two heavy steel channels, set back to back, and two plates riveted to the flanges of the channels. They are made in two-story lengths, with the splice joints staggered, so that in each story there are joints only in alternate columns. The details of columns and

connections vary with the size and location of the column, but the typical plan of construction is as shown in Fig. 2. The main floor beams are in pairs, separated by the width of the column, and each beam rests upon a bracket, A, riveted to the side of the column. By this arrangement all loads are transmitted axially through the column. At the outer wall of the building the floor beams extend beyond the columns, forming cantilevers, which carry the masonry of the walls, the walls being supported at each floor by the beams connecting the ends of the cantilevers. Gusset plates above and below the cantilevers serve as wind bracing. On each floor there is a system of wind bracing by portal arches, as shown; while between the fifth and sixth floors there is a system of vertical diagonal bracing between the columns. The main floor beams are principally 15-in. I-beams, with smaller transverse I-beams riveted to their webs. The steel for columns was specified to be of "medium" grade, with an elastic limit of not less than 30,000 lbs. per sq. in.; a minimum elongation of 22% in 8 ins., and to bend cold 180° flat on itself over a mandril of 1½ times the diameter of the piece tested without showing sign of rupture of fiber on either surface.

It will be noticed by the section in Fig. 2, and the floor plan in Fig. 3, that the columns are not built into the exterior walls and inclosed by them (as is the common practice in steel skeleton construction), but are placed beyond the inner lines of these walls, the masonry being carried by cantilevers as above described. Mr. Post does not consider it good practice to embed the steel work in the masonry, where it cannot be inspected as to its condition after a term of years of service. One reason for this is that there is yet no reliable or sufficient experience as to the life of or changes in steel thus embedded in concrete or masonry, and another reason is the practical impossibility of keeping water away from steel so situated. Water from a broken water main or other source flowing against the foundation masonry will gradually penetrate the masonry, and no amount of waterproofing or protective paint will serve to absolutely protect the steel when moisture has once passed through the masonry. During the construction of the Mills Building, the walls of which are of hard burned pressed red brick, laid in Rosendale cement mortar, a heavy northeast storm driving against the reentrant angle of the walls perpendicular to the Wall St. and Broad St. fronts, caused the rain to pass through the masonry (which is 4 ft. to 5 ft. thick at the angle). Columns embedded in the masonry are also more likely to be affected by the heat from adjacent burning buildings.

In the St. Paul Building, therefore, the wall or abutment columns are placed 6 ins. clear from the inner face of the wall. Each column is encased in hard burned porous (or sawdust) terra cotta fireproof tiling, 4 ins. thick, and the outer spaces between the channel webs and the fireproofing are filled with cement mortar. Outside the fireproof tiling, between it and the outer wall are laid two courses of heavy tarred felt.

The steel work is given two coats of graphite paint at the shops, and another coat after erection. This is a special paint, and is composed of a good graphite, best linseed oil, and first-class Japan varnish as a drier. Besides this, all the steel work below the ground surface is heavily coated with asphalt. By the above arrangement of columns, independent of the walls, any signs of failure after, perhaps, 50 or 60 years' service, will be made evident by the cracking or bending of the work, as steel is not likely to crack short off like a pipe stem. In such a case the columns can be readily stripped for examination for fracture or corrosion, and if found defective can be removed and replaced with a new section. This arrangement was originally planned for this building, but has also been employed by Mr. Post in the Havemeyer stores, in the Meyer Jonasson building, at the corner of Broadway and 12th St., and (with some modifications) in the Park Building, at Pittsburg, Pa.

The floors are of hollow tile. This material is preferred on account of its lateral strength and resistance to other forms of floor, which, though advantageous in lightness of weight, are relatively strong and rigid only in a vertical direction.

The floor plan, Fig. 3, shows the arrangement of the main floor system, and the layout of the offices, and the solid and glazed partitions, doorways and plumbing. There are six elevators arranged in a segmental well, and one of these will be for carrying safes and other heavy furniture. The open space shown behind the elevator well or shaft will contain the hoisting apparatus for the six cages. At the back of the building are the smoke-stack shaft and the stairway, and on each floor there are two closets, one at the back of the building and the other next to the elevator shaft.

The owner of the property and building is Mr. H. O. Havemeyer. The architect and engineer is Mr. Geo. B. Post, and the contractors are Robinson & Wallace, of New York, while the structural work is being built and erected by J. B. & J. M. Cornell, of New York.

THE DULUTH, WINNIPEG & HUDSON BAY CO. is the ambitious title of an enterprize now being promoted in Duluth, having for its object an inland waterway from Duluth to Hudson Bay. The plans call for some astonishingly heavy engineering work; including a tunnel through the Mesaba Range and a rise of 627 ft. between Duluth and Rice Lake. The cost is estimated at $18,000,000 and "national and state aid is to be asked for." It will doubtless be needed. The Bessemer iron ore to be found in tunnelling the Mesaba Range is expected to assist in defraying the cost of construction; and electricity generated by water power would be utilized in operating the canal.

ANOTHER CAPE COD CANAL PROJECT is embodied in a report of the Massachusetts Senate recommending the incorporation of the Massachusetts Maritime Co., having for its object the building of a canal across Cape Cod by the Bass River route, with a capital of $6,000,000.

THE RIVER AND HARBOR BILL, as finally amended by the U. S. Senate, carries an appropriation of $12,444,550. The total of improvements, placed under the contract system and to be provided for by future appropriations, is now $60,225,613.

THE FORTIFICATION BILL, prepared by the House Appropriations Committee and presented to Congress, authorizes a total expenditure of $11,394,613, with $5,842,337 for specific appropriations and the remainder to cover contracts to be made by the War Department. The principal items are gun and mortar batteries, $5,260,000; sites for fortifications, $250,000; repair of fortifications, $50,000; harbor defense torpedoes, $100,000; armament for forts, $5,502,875. This last item covers the immediate manufacture or purchase of 12 8-in., 18 10-in., 18 12-in. and one 16-in. high-power coast defense guns, to cost not exceeding $1,332,068. Other items under this head cover 81 gun carriages for 8-in., 10-in. and 12-in. guns; 60 12-in. steel mortars and carriages; deck-piercing and armor-piercing projectiles, etc. It is estimated that 52 8-in., 62 10-in. and 43 12-in. guns will be completed by June 30, 1897.

NEEDED IMPROVEMENTS TO THE PHILADELPHIA gas works are the subject of a recent report by Mr. Thomas M. Thompson, Director of Public Works, to Mr. Jacob J. Leeds, Chairman of Council's Committee on Finance. Mr. Thompson estimates that an expenditure of $1,500,000 in improvements needed to bring the works up to date would result in an annual saving of $600,000 through reduced cost of operation and diminished leakage. With these improvements gas could be furnished to private concerns at 75 cts. per 1,000 ft., provided the city would pay for the gas consumed for public purposes. The bulk of the expenditure for needed improvements would be for new mains and holders.

OIL GAS LIGHTING FOR CABLE CARS is to be introduced on the Westport line at Kansas City, Mo., the Pintsch compressed oil gas system being employed.

NATURAL GAS is still quite abundant in the vicinity of Pittsburg, according to the annual report of the Philadelphia Co. The gross earnings of the company for the year ending March 31, wer $1,311,669.96; operating expenses, $926,898.90, leaving net earnings $384,771.06, or about 4% on the assets, which amount to $9,517,266.83. Dividends amounting to $150,000 were paid during the year. The operating expenses include $267,600.27 for new gas wells, $65,588.65 for new oil wells, and $88,850.11 for prospecting. In addition to the operating expenses charged against earnings, a new line to West Virginia was constructed, costing $814,854.82, of which the Chartiers Valley Gas Co. pays $209,026.44, leaving $605,827.58 for the Philadelphia Co. to pay. During the year 88 wells were drilled, of which 48 produced gas, 18 oil, and 22 were non-productive. The total number of gas wells owned by the company is 297, with 36 oil wells, producing a daily average of 300 barrels of oil per day. The discovery of natural gas in large quantities in Greene Co., Pa., and in Wetzel and Tyler counties, W. Va., made it advantageous for the company to spend some of its surplus to continue a supply of natural gas, and in consequence nothing has been done towards the erection of the proposed fuel gas plant on Brunotsland. It also gives the opportunity to the Philadelphia Co. to await the result of experiments on fuel gas by other parties before proceeding with its own plant.

THE LARGEST CHIMNEY in this country has just been erected by the Pennsylvania Salt Mfg. Co. at Natrona, Pa. It is made of steel plates, and is 200 ft. high, 41½ ft. in diameter at the base and 28½ ft. at the top. It is lined with fire brick. It is used to carry off the smoke and objectionable chemical vapors made by the works.

THE CITY ORGANIZATION'S FILTRATION COMmittee of Philadelphia is to continue the fight for pure water in that city. It is composed of representatives of 24 business, reform, educational, engineering and other associations or institutions, and its sole object is to secure the filtration of the city's water supply.

THE PAPER PULP PAVING made at Topeka, Kan., is appearing on the market in competition with other paving materials. Bids were recently received for about 15 miles of sidewalk paving, and Mr. W. P. Emery, the inventor of the paper pulp paving, bid 7.2 cts. per sq. ft. The contract was awarded, however, to a bidder who offered vitrified brick paving at 5.49 cts. per sq. ft.

THE PARA-MANAOS ELECTRIC CABLE, for connecting these two Brazilian cities by way of the bed of the Amazon River has just been laid by the cable-steamer "Faraday." The length of the cable is 1,400 miles and its estimated cost, ready for operation, is $1,050,000. The Brazilian government has given the company a bonus of $85,000 per year for 30 years and at the expiration of that time the ownership of the cable reverts to Brazil. The importance of better communication between these two centers of the rubber traffic is the incentive in this enterprise; and all previous attempts to maintain aerial electric lines have failed owing to the rapidity of tropical growth and the interference of monkeys and other animals.

THE HUNGARIAN NATIONAL EXHIBITION, at Budapest, was formally opened on May 2, and will continue until Sept. 27. This exhibition is to celebrate the millennial anniversary of the nation, and will be largely of a historical character.

A UNIVERSAL CENSUS is proposed for the year 1900, and the proposition was discussed at the meeting of the International Statistical Institute, at Berne. A committee is to be appointed by the institute which is to advise as to the most convenient date for the census, and to determine and formulate important questions of general interest, leaving each country to supplement these as they deem fit. The terms to be used in the census papers should also be accurately defined, so as to avoid ambiguity and to obtain identical results; and, most important of all, the committee is to offer suggestions as to the best means of obtaining united action in several countries. This committee is to report at the next meeting of the institute in 1897.

IMMIGRANTS TO THE UNITED STATES, in the 25 years, 1871-1895, inclusive, numbered 10,339,539, according to the last report of the U. S. Bureau of Statistics. Of this number 33.75% were females. From the British Kingdom came 2,956,259, nearly one-half being Irishmen; Germany, Austria and the Netherlands sent 3,078,469; of the Latin races the immigrants numbered 877,634; Scandinavians, 1,151,210; Bohemians, Hungarians, Poles and Russians, 986,676; and the total of Europeans for the 25 years was 9,197,014. In addition to these, Chinese and other Asiatic races contributed 227,037; British North America supplied 776,071 up to 1885, since which time they were not reported, and immigrants from Central and South America, the Atlantic and Pacific Islands and other countries not named above make up the balance. The population of the United States by the 1870 census was 38,558,371; in 1895 it was 69,753,000; showing an increase of 31,194,629 in 25 years, with 33.15% of this increase foreign-born.

AN APPARATUS FOR ATTACHING STAMPS to envelopes has been patented by Fritz Gauger, Jr., of Zurich, Switzerland. It is simply a rectangular box fitted to hold 200 stamps, piled one on the other gummed side down, with two little hooks at the bottom holding the stamps in place. A pad is provided for moistening the stamps, and a downward pressure on the vertical handle of the box releases the two hooks and pastes down one stamp. It is claimed that with this apparatus envelopes can be stamped at the rate of 1,200 to 1 500 per hour. For general use a special stand is provided carrying boxes for three or more values of stamps with the moistening pad in front. Mr. Joseph H. Nevel, of Zurich, is the agent for America.